IMPACT OF ROBOTS AND COMPUTERS ON THE WORK FORCE OF THE 1980's

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HEARINGS

BEFORE THE

SUBCOMMITTEE ON GENERAL OVERSIGHT
AND THE ECONOMY

OF THE

COMMITTEE ON SMALL BUSINESS
HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

WASHINGTON, D.C., MAY 17 AND 18, 1983

Printed for the use of the Committee on Small Business

U.S. GOVERNMENT PRINTING OFFICE
31-912 O
WASHINGTON : 1984

H 721-13

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CONTENTS

Page

Hearings held on:

May 17, 1983 1
May 18, 1983 133
Bedell, Hon. Berkley, chairman, Subcommittee on General Oversight and the Economy: Opening statement with additional submissions 1, 133

Testimony of:

Abraham, Katharine G., assistant professor, Sloan School of Management, Massachusetts Institute of Technology 166
Blumenthal, Marjory S., project director, Computerized Manufacturing Automation, Office of Technology Assessment; accompanied by Fred Weingarten, manager, Communications and Information Technologies Program, Office of Technology Assessment 17
Canada, Peggy, manager of training and development, Cox Cable Communications 214
Etzioni, Amitai, professor, George Washington University 180
Gordon, Theodore, president, The Futures Group 53
Helms, W. Clyde, Jr., president and founder, Occupational Forecasting, Inc 89
Hunt, H. Allan, acting manager of research, W. E. Upjohn Institute for Employment Research 34
Kutscher, Ronald E., Associate Commissioner of Labor Statistics, U.S. Bureau of Labor; accompanied by Neil Rosenthal, Chief, Division of Occupational Outlook 134
Loble, Leslie, legislative representative, Communications Workers of America; accompanied by Mike Dymmel, expert in training programs, CWA 196
Weisel, Walter K., president, Prab Robots, Inc., and president, Robot Institute of America; accompanied by Donald A. Vincent, executive vice president, RIA 3

Additional material supplied for the hearing record:

Abraham, Katharine G., assistant professor, Sloan School of Management, Massachusetts Institute of Technology: Prepared statement 173
Blumenthal, Marjory S., project director, Computerized Manufacturing Automation, Office of Technology Assessment: Prepared statement 22
Canada, Peggy, manager of training and development, Cox Cable Communications: Prepared statement 222
Etzioni, Amitai, professor, George Washington University: Prepared statement 187

Gordon, Theodore, president, The Futures Group:

"Global Consequences of Improving Productivity," by Theodore J. Gordon and John Stover, paper 71
Prepared statement with attachments 61

Helms, W. Clyde, Jr., president and founder, Occupational Forecasting, Inc.:

"A New Era for Management," article, Business Week, April 25, 1983 124
Prepared statement with attachments 96
Hunt, H. Allan, acting manager of research, W. E. Upjohn Institute for Employment Research: Prepared statement with attachments 39
Kutscher, Ronald E., Associate Commissioner of Labor Statistics, U.S. Bureau of Labor; accompanied by Neil Rosenthal, Chief, Division of Occupational Outlook: Prepared statement 140
Loble, Leslie, legislative representative, Communications Workers of America: Prepared statement 201

APPENDIXES

	Page
Appendix A.—Questions to and responses from Westinghouse Electric Corporation	227
Appendix B.—"The Impacts of Automation on Employment, 1963-2000," abstract and executive summary of draft final report, by Wassily Leontief and Faye Duchin, March 1984	229

IMPACT OF ROBOTS AND COMPUTERS ON THE WORK FORCE OF THE 1980's

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TUESDAY, MAY 17, 1983

House of Representatives,
Subcommittee on General Oversight
and the Economy,
Committee on Small Business,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:32 a.m., in room 2359-A, Rayburn House Office Building, Hon. Berkley Bedell (chairman of the subcommittee) presiding.

OPENING STATEMENT OF CHAIRMAN BEDELL

Mr. Bedell. The subcommittee will come to order.

In what the Washington Post called the quiet revolution robots are making their way into American life. Their less celebrated but, in some ways, more significant siblings, numerically controlled machines, are coming with them. With the computer as the brain power behind this revolution, workers are uncertain about the consequences of the integration of the steel collar without lunch buckets who have come to join them.

During the long march of the history of technology, tools of all kinds have been invented to extend the arms and legs of mankind. But these were tools to extend man's muscle, to speed up initiated motion, to lift things too heavy for humankind, and to generally extend the reach and ability for man. The robot comes not to extend man, but to replace him. It comes also to do some of mankind's dullest, dirtiest, and most dangerous work. If one were to accept as gospel the popular press, one might conclude that R2D2 is, indeed, going to take over the world. But is he? Should he? What is it that robots, CAD/CAM and other systems can do?

What are their limitations? These are among the questions we will want to direct to our first witness, Walter Weisel, a national expert on this who serves as president of the Robot Institute of America. There are as many interpretations as there are analysts when the question is asked as to how fast robots will come. As Members of Congress who must make some attempt to fashion public policy, it is important to get the most reasonable assessment we can.

From the witnesses today and tomorrow we will hear those assessments and try to reach some consensus as to what the impact is more likely to be.

The project being undertaken by this subcommittee and out of which these hearings come, is an overall analysis of the employment future of Americans. Jobs, or the lack of them, will be the focus. Where are the jobs of the future coming from? How many will be employed, and how many will be unemployed? What will be the nature of the jobs we do?

Analysis of where people work and the classification of the occupations is a function of the Bureau of Labor Statistics. Nearly all projections of the jobs future whether made by the Government or by private analysts from Data Resources, Chase, Wharton, or whatever, use BLS numbers as their basis.

We will look at these numbers when Ron Kutscher of BLS testifies tomorrow. We will hear a sharp criticism of BLS procedures from Clyde Helms later today.

While not reflected in current BLS projections, there seems to be a growing feeling among specialists that structural unemployment is increasingly with us, perhaps here to stay. Yesterday's New York Times had a front page story, the subheading of which read, "Big Corporations Rely on Automation to Aid Output in a Recovery." In the story, James H. Evans, chairman of the Union Pacific Corp. said that 6,000 of his company's 44,000 employees were on layoff. "Will they come back?" he was asked. His response was:

> The answer is probably not. We're running 40 percent more freight tonnage than we did 20 years ago with half as many employees. If we had the same number of employees we had then, we would have priced ourselves out of the market. How have we done it? Automation.

The relationship between structural unemployment and automation is very real even though argument persists about its precise definition. Structural unemployment, now estimated by the administration at 6.5 percent, is the highest since the depression. These people are generally out of work permanently.

I must ask myself whether or not I will live to see the day when the unemployment rate in the United States falls below 7 percent. If such numbers remain unemployed what should America do? What policy should be pursued by Government, by industry, and by labor, to address this problem? As the country moves seemingly inexorably from a manufacturing or industrial economy toward an informational society with increasing use of technology, we are faced with increasingly serious problems of training and retraining the work force.

If we are faced—as Professor Abraham will testify—with a situation in which 10 or more people want a job for every job which exists, training in and of itself will, of course, not solve the problem. This does not diminish the need for training. There is a growing mismatch between what our people are trained to do and what is out there to be done.

The National Commission on Excellence in Education offers to the Nation a chilling analysis of the inadequacy of our basic education to train young people with the skills needed to cope with the world they are inheriting.

The speed of changing technology constantly reduces the half life of the skills of the work force. One industry spokesman in the high tech computer sector indicated that the half-life of skills was down to less than 3 years. Obviously, a rigorous training and retraining program must be a part of our effort to cope.

Tomorrow we will have witnesses from both labor and management, who will report on what is being done to keep the skills of the work force updated. But no witness could be found who could argue credibly that in our rush to high tech we can retrain the 50-year-old steelworkers as a group to become computer programers.

Mr. Olin, did you have a statement?

Mr. **Olin**. No.

Mr. **Bedell**. Mr. Boehlert.

Mr. **Boehlert**. No.

Mr. **Bedell**. Mr. Bilirakis.

Mr. **Bilirakis**. No.

Mr. **Bedell**. If not, we will come to our first witness who is Walter Weisel. He is president of Prab Robots, and president of the Robot Institute of America. We will ask you to introduce the gentleman who is with you, Mr. Weisel. We are looking forward to your testimony, and we appreciate your being here.

Mr. **Weisel**. OK. Thank you, Mr. Chairman. I appreciate the opportunity to be here.

Mr. **Bedell**. Would you introduce your colleague here with you?

TESTIMONY OF WALTER K. WEISEL, PRESIDENT, PRAB ROBOTS, INC., AND PRESIDENT, ROBOT INSTITUTE OF AMERICA; ACCOMPANIED BY DONALD A. VINCENT, EXECUTIVE VICE PRESIDENT, RIA

Mr. **Weisel**. This is Don Vincent. Mr. Vincent is the executive vice president of the Robot Institute of America.

I might just say for the record that RIA is the official U.S. trade association for all industrial robot manufacturers in the United States, and we also have a user group which is part of our membership.

The total membership of the organization encompasses about 200 companies. I would estimate better than 50 percent would be considered to be small business. The rest would be fairly large corporations in the United States.

I have been asked this morning to provide a basic overview of the health of the industry, and to try to provide some education with respect to what a robot is and why we have them? Why do they get so much attention? My talk is about robots: What, why, where, and when.

Now to do this I have brought some slides. If we can have the lights dimmed, I want to give you some statistics and background about the history of the industry.

First of all, I think it is virtually unprecedented that robot technology, which has a total U.S. output of about $250 million, commands the kind of attention that you see in the media, and certainly by this committee.

I recently spoke to Mr. Baldrige with his group at the Department of Commerce, and there was a general awareness at the management level, at the labor level, and so on. I think it speaks for the importance of the technology and the type of attention that it is getting, an absolute vital tool to the productivity and the increase in productivity that this country has to make if we are going to stay a real world industrial power.

The history goes like this: In 1958—which may surprise some of you—the first industrial robot was born. It was installed in approximately 1960, which means that industrial robots have really been around for about 22 years.

In the late 1960's, after little or no acceptance in the United States, several of the U.S. manufacturers involved at that time turned overseas, and the Japanese picked up the technology under license from two U.S. companies and began production of their industrial robots in about 1970.

In 1970, after 10 years on the scene, the United States had installed about 1,000 machines, with the majority of all those machines being installed in the automotive industry for body spotwelding. I will show you an example of that in a moment.

By 1980, the U.S. robot population was approximately 5,000 machines, and by 1980 the Japanese had installed about 12,000 machines.

I am going to draw some comparisons later between the types of machines being used in Japan and the United States, but clearly the technology was picked up and used in the factories of Japan much quicker than it was in the United States. I believe that we were somewhat complacent. We did have good output and good economic conditions at that time.

In looking through some of the material to be presented, it is projected that the use of industrial robots in the United States by 1990 should reach about 80,000 to 100,000 machines. That goal is equivalent to about a $2 to $3 billion industry, which is roughly the equivalent to the U.S. machine tool industry.

I would tell you that I, as president of the trade association, don't begin to believe that can be achievable unless two things happen: One, that we see a major turnaround of the economy on a world scale by the end of 1984, and two, that we undertake a massive effort to train management, process engineers, and laborers on how to cope with this technology. It is not particularly difficult. It is not far out. It embodies computers, arms and things that I will show you in a minute. Basically we are in the education business in the United States.

Robot manufacturers who have salesmen out on the street every day are educating manufacturing people on the basis of what robot technology can do.

It is pure folly to think that an industrial robot can walk in off the street, and go to work. It takes a tremendous amount of effort, manpower, and dollars to install this equipment, and I will show you the complexity of some of these installations.

Your committee is really looking at the robot as part of CAD/CAM, and flexible manufacturing systems. I would contend that a flexible manufacturing system would be virtually impossible without having the basic attributes of a robot tied to it. It is such a vital part of a system that it really ends up drawing the various technologies of CAD and CAM together to make a total handling system in a factory.

Now, let's get to the "why" of industrial robots. First of all, it is a minimal risk piece of equipment, because as said earlier, we had about 6,800 machines installed at the end of 1982. If I go forward two slides, you will see the production line of machines—the green portions of the slide, and the machines themselves are very disappointing looking.

Those school kids that come to visit us are quite disappointed. I will make it clear that we are talking about industrial robots on my part of the presentation, and not the home or show-type robot, which are also gaining quite a bit of notoriety.

For instance, my company has built 1,500 machines, and you tend to work out the bugs after 1,500 machines. The risk that goes into installing one of these the next time you put one in is fairly minimal.

Another advantage is the reduction in price. Once the robot manufacturer has built enough equipment, standardized on the components and the installations, then the price comes down. It is fairly simple to put them in with the exception of the interfaces and the grippers, and that type of thing.

But back to the "why." Here is a man standing at the action end of a robot arm, and if you look at the orange part of the arm, attached to it with all the hoses is a spotwelding gun that is used to weld a car body. What he has in his hand is the same device I am holding. This device is used on virtually everyone's robots and is a common type of teaching which allows the operator to drive the arm around in space, either hydraulically or electrically. For instance, if I want to move this cup from this point to this point, I take the teach box, called a programing aid, and I merely go out, grab the cup, pick it up, move it to the side, set it down, pull it back, and I will have recorded that position in the robot's memory.

Now, you can get very sophisticated and very complicated in programing the job itself. However, the programing is relatively straightforward, simple, and I guarantee I could take any one of you on the podium and in a matter of 30 minutes make you a real robot programing expert; that is a fact.

I think that should be a point that you keep in mind when discussing how we convert laborers who handle hot, heavy parts and presses in the robot program. A robot programer is not necessarily a Harvard Business School graduate who understands computers. He is a person who understands what the arm is supposed to function like on the jobsite.

Again, I say that virtually every robot manufacturer builds standard components, or standard products, and the programing is the key. None of the robots shown in this photo know what their application is until they have actually gone out on the job site.

Now, what can robots do for reach and speed? Here, you see one with its reach and area are outlined in blue. This is what this particular robot looks like. That machine can reach out 10 feet in space; it can swing around or cover 20 feet overall. It can take a 100-pound part, move it at an extremely high speed, on a repetitive basis around the clock, and it can repeat any taught point, as I showed you, by moving the cup within 0.008 of an inch.

There are also robots that can get down into one-thousandth or two-thousandths of an inch. In many cases, we are going after jobs, and we are taking jobs that humans are not performing. It is done by other forms of automation, and I think you will see in a little bit that in many cases, robots really don't compete solely with people. They compete with hard automation and other ways of performing a particular job.

There is another type robot that actually moves around on the floor, able to cover the area outlined in blue, and I will go into some applications of its capability. On this machine, the orange and white parts make up the machine. Out at the lower righthand side of the robot, you see a round, solid steel part. That part weighs around 125 pounds. You can't carry it around with you; you need an operator. The robot then walks up and down the aisle or traverses up and down the aisle and loads the battery of machine tools. Although a robot is looked upon as possibly an outgrowth of an NC machine tool, in no way does it restrict its application to the machine tool industry, or to machining. It crosses all lines; and what we are dealing with here is a technology that is impacting virtually every industrial manufacturing process in the country.

For instance, these are headlights for automobiles. This robot tests them, takes them out of machines, puts them through testing procedure, and packs them in boxes.

A television tube is taken off a moving monorail, swung around at high speed, with delicate handling. Incidentally, this is a very dangerous job for a human since TV tubes implode if you break them. They are extremely dangerous.

Here is a job where the orange machine is a robot. On this end, another robot is grinding the inside of a stainless steel sink, so we are using hand-to-hand coordination to do grinding.

Here, a robot on the left side of the screen is taking a 600-degree part out of a die-casting machine, which is an extremely hazardous application. There are about 600 to 700 of these machines installed in the United States, and the robot has played a very key role in keeping the die-casting industry competitive.

Here we are taking hot parts, quenching them, going into trimming presses. Here is a machine, on the left. You can see the end of its arm coming out. We are picking up the small engine part out of the molten metal foundry. This job has been in operation about 3 years, on a couple of shifts without grievances for cataracts, sterility, back problems, or foot injuries. This shop, incidentally, employs about 16 people, and it has 3 robots.

Here is a sand-pour foundry, which has a very bad environment, with toxic fumes; again, a robot in a hostile environment.

I wish I had the slides of this job before the robot was installed. This man had on an asbestos outfit with a hood. These are the inner cores of electric motors, and his job was to take the core, dip it into a solder, go into a hot, molten flux machine, where the part very quickly caught on fire. His arms would be on fire. At that point, he would shake off the excess flux, and put that part on the table.

Today the operator acts as an inspector. He puts the parts in for the robot; the robot does the dirty part of the job, and he in turn does inspection and output into the other part of the factory.

I want to give you a feel for the range of the dollars involved in robot equipment. Robots that you are looking at here can sell installed for approximately $25,000 up to about $150,000. Typically a system would run anywhere from about $50,000 to several million dollars, depending on the complexity of the other computers and work process technology involved.

This is a robot handling a 2,200° part, going into a forging press. This is an extremely bad job with many injuries. There is a whole battery of robots in this country working in hot forging shops.

Here is one that the OSHA people say is a real no-no. Our country is filled with big presses, whether they be stamping presses, molding presses, diecasting presses, or whatever, and we have got people all over the place losing their arms, having problems with their backs.

This slide happens to be of a job at Hoover Vacuum Cleaner in Cleveland. A lady is taking two vacuum cleaner components out of this compression molding machine. She is now backed over to the right of the slide. The robot goes in and takes out the two pieces, comes across, puts the two pieces into a trimming station with the trimming of the excess materials taken off, and she acts as an inspector and a packer.

All of the applications that I have shown you so far have carried at least a minimum increase in productivity of about 20 to 30 percent. Now, another fairly staggering statistic is that about 90 percent of all U.S. robot shipments are installed in existing manufacturing processes.

We take a real hard look at what it means to increase the productivity of machine tools and presses about 20 to 30 percent by investing $25,000 to $100,000. It comes fairly quickly. You see why manufacturing managers are waking up to the benefits of robot automation.

Mr. **Bilirakis**. Mr. Weisel, excuse me, sir.

Mr. Chairman, may I interrupt at this point?

Mr. **Bedell**. Of course.

Mr. **Bilirakis**. You have told us about the increase in productivity. Has there been any decrease in jobs in the application that you refer to?

Mr. **Weisel**. Yes. I would say that you are probably looking on most applications of a reducton of about three-quarters to about one person per application.

Mr. **Bilirakis**. In all of these applications that we have seen?

Mr. **Weisel**. Yes, sir.

The ones where the process involves keeping a person involved in inspection; and in a sense it is awash, and the cost justification comes out of increased productivity and quality. Once you get some of this machinery running on a repetitive basis, quality tends to go up, and you reduce your scrap significantly.

Mr. **Bilirakis**. And without the robots, if you had pointed for a 20 percent increase in productivity—would that have been possible and if it had been—how many employees would it have taken to reach that point without robots?

Mr. **Weisel**. I would say generally it is pretty well accepted by robot manufacturers that the human worker is a tremendous piece of automation. If people want the job, we are not going to have a chance at it.

Generally the reason there is an increase in productivity is because of the weight or the reach, and it becomes a stress factor on the person over an 8-hour shift. We teach our robot salesmen to look at a job with one hand behind their back, and try to do what a person is doing with two hands. Very rarely can you beat the speed of a person if the person really wants to take the time to give maximum output. The problem is that across 8 hours or a couple of shifts, the human tends to hit fatigue, and the robot doesn't. It is very strong, very high speed, very repetitive.

It isn't how many more people could you throw in the process to make it faster. It is a fall-out of the automation process.

This happens to be a very large injection molding machine, and that part in there is a garbage can. We have laborers, incidentally, working very hard to keep this robot in production. They pull up in front of your house every other day or so and try to destroy that part. That plant is working a couple of shifts, and those robots have been installed for a good number of years.

Here is a machine that the press is so big, and it took two people to walk into the press to get the part out. One robot here has displaced one person, and one of the two people stayed on the job for packing and inspection. The white machine is the robot moving into a 3,000-ton injection molding machine. Once it backs out, what it has got is a household door, and we thermo-pressed a door which actually gets a piece of glass in it and becomes in the housing industry.

This robot is going into a stamping press. There is a person working on the other side of the press, which is feeding parts in. This robot happens to be taking the part of the job where we are actually doing multistage maneuvering of the part within the press, and these are microwave ovens.

The appliance industry is a fairly prime candidate for industrial robots because of the high volumes and types of processes.

Now, this robot is servicing three machines and the gray part in the end of its hand, which is more toward the left of the picture, is the front end of a Pontiac Grand Prix. I might add that this happens to be at a very small business, which is an automotive supplier, and through the implementation, this particular customer was able to take about 47 cents out of the part, which really kept him competitive, and did quite a bit for him as a supplier to the automotive company.

Machine tool loading and unloading is a big market. Here you see one robot tending three machine tools, the parts coming in two stages are differentials for trucks. This happens to be at an Eaton plant. But the application of robots to the machine tool base installed in this country is virtually untouched.

Here this robot is picking up transmission cases. They were 26 pounds apiece, coming off an inspection machine, going to a moving hook. This job was actually a grievance job at the company because of the back injuries. One is a relief man; and one is an actual operator to run this application. One robot was installed for $35,000; the laborers labeled it the iron monkey, and just from an acceptance standpoint, I want to tell you that labor is not hostile to this form of automation. I can address myself to that a little bit more later, if you like.

Arc welding is a very big market. We need some sensor breakthrough in the technology to really make it a viable application in large volumes. But there are problems in the factories today with the fumes from arc welding, and productivity increases on this job are fairly staggering because the man here in this case has to use his eye whereas the robot pretty much knows where the path is, and he can do it much quicker.

There is a lot of noise made about how many machines will be used in small parts programable assembly. To date there have not been a lot installed. In the future, with sensor breakthroughs, and forms of vision, tactile sensing, I would see more application of industrial robots in small parts assembly application.

This robot is taking a tray of sterilized bottles out of a hot sterilizing machine and picking them up 80 at a time.

The point I have tried to make in showing this is that I have tried to stay away from the big automotive companies, the big spotwelding lines which are typically what you read about in the press. I have tried to show you where the machines are in applications other than automotive, and you can see that they spread to virtually every sector.

Now, the robot revolution, in my opinion, is largely brought about by the discovery of one thing by two parties; one party being the press, which is having a very good time writing about star wars and robots. I have been in the robot business almost 13 years. I started when you couldn't give them away, and I am really glad to see all the press.

Second, a group of people who have discovered robots is the manufacturing management, and where they discovered it was in Japan. When they finally woke up to go overseas and figure out how in the world could they bring these products into the United States at such low prices and yet afford the freight and the duties and everything to go with it.

I like to use an example about unemployment. Ten thousand robots will unemploy 300,000 people, and I have said this in front of labor groups all over the country, and I get a big smile at the end, because the 10,000 robots that were installed in Japan in the automotive industry have had a large impact on their ability to import and take away 30 percent of our market, and unemploy 300,000 U.S. workers.

The point I want to make in closing is that the United States has no curb on this technology. We started it in the late fifties. We are just now learning to use it. We have exported it. We are ahead to a certain degree in sensor base technology. But the thing that is important is that every single process that you saw on the slides is being done in France, Germany, Spain, Japan, all the Far East, and Middle East, and it is an applications race. It is a race by nations. I attend international meetings where they fight to see which country hosts the next big international robotics conference, and major people sit around and brag about how many robots they have got installed because it is a national prestige.

It is estimated by the year 1990 world production of industrial robots will be roughly $9 billion to $10 billion. We are estimating that we may see $2 billion to $3 billion of that market in the United States. The reason it is so low, when you stop to consider that we are one of the largest industrial nations in the world, is that I don't think we have got the trained people to cope with installing this level of machines. I don't think it is that difficult. I believe our schools are responding well. I think there is a lot of very good work being done between labor and management with respect to retraining.

Take the example of whether a floor sweeper can become a computer programer? No; he never will be, but he may be a robot programer; and the machine operator may be the line foreman, and the line foreman may be the electronics technician; and the electronics technician may turn into a computer programer. It is a general spreading of the wealth. It is an upgrading, just as we have seen in the computer industry and seen in the machine tool industry, and so on.

In closing, I would like to say that while I appreciate the opportunity to make our point, I think the important thing that we have to get across is that it is here; it works; we don't have to research it to death; we have to use it; we have to find ways to give companies incentives to use it. Small business in the United States is not the fair-haired cousin of the big company like it is in Japan.

Small business takes a direct interest in the automation they buy. It is a major investment for them, and I don't think it has the kind of displacement attached to it at the small business level that it does with a large company because people tend to serve across broader lines, and I believe that it is absolutely a vital technology to our future, and I thank you.

Mr. **Bedell**. Thank you very much, Mr. Weisel.

Mr **Olin**. Mr. Chairman, I don't really have too many questions for the gentleman, but I would like to make just a statement.

I spent about 30 years of my life in industrial automation with the General Electric Co. as a user of automation and a designer and seller of it, and would like to make the observation that the advent of robots has been an extension of a process that has been going on for probably 50 years in industry, of gradually automating and doing things more mechanically, to lower the cost of doing them, and to get the benefit of generally the higher quality that results from that.

I think that in the period after World War II, our American industry moved very strongly in many respects toward automation. We didn't call the machines we put out at that time robots, but many of them were a very similar technology. They were things that picked up parts and moved them someplace, and put them down. They were not as sophisticated in terms of their degrees of freedom and their flexibility as the present type of products, but they were nevertheless the same general idea.

Let me ask the gentleman whether you feel that with the advent of this new stage of automation, which requires, of course, a computer programer and service people; and quite a few jobs involved in making these robots. There is a huge market for them throughout the world and the United States. Whether you feel that even though the robot itself, when applied, may replace human workers in that application, and whether the net result of all of it, when you consider the servicing and the making and the computer programing and the broader application, whether this really does represent an opportunity to increase jobs in the United States.

Mr. **Weisel**. I think there is a good possibility that it will. I think that at a minimum it is going to equal itself out. When we look at roughly 6,800 machines installed now after 22 years, that is not a very big record to brag about, but I know that we have considerably more people in the United States addressing themselves to robot kinds of things, other than 6,800 people.

If we were successful in putting in 100,000 machines by 1990, my estimate, and the trade association's estimate is that we would probably have generated about 350,000 to maybe 400,000 jobs, and those jobs would be everything from salespeople, applications engineers, research people, field service technicians, and then at the user level you would have your maintenance people and manufacturing process people. You can read estimates from one end of the spectrum to the other, but our estimate is that it is going to pretty much be awash.

Mr. **Olin**. I would tend to agree with that, Mr. Chairman, and I think we ought to look at robots as a jobmaking opportunity as well as one which changes our jobs.

Thank you.

Mr. **Bedell**. Thank you.

Mr. Boehlert.

Mr. **Boehlert**. Thank you, Mr. Chairman.

Where is the principal research being conducted in robotics? Is it the university community, in the private sector, or is there a combination of the two?

Mr. **Weisel**. I think we would say more in the research community at this point.

Mr. **Boehlert**. Funded where? By the Bureau of Standards?

Mr. **Weisel**. Some of it there, and some by private consortiums. A team of 15 companies would team up to sponsor a research program. But the amount of research that is going on isn't near the magnitude that you might suspect.

Mr. **Boehlert**. Do you have any figures on that?

Mr. **Weisel**. No, I don't.

Mr. **Bedell**. Would the gentleman yield?

How would our research compare with that of Japan, France, or Germany or some of the other industrialized companies?

Mr. **Weisel**. I think that against Europe, we are certainly putting more money back into technology than they are.

In Japan, I am concerned they are just throwing people at the development of sensor technology and more sophisticated robots.

You see, one thing that you ought to be careful of when you get all these figures thrown at you is, that the difference in the way Japan counts what they call robots and what the United States counts as robots because you are going to get figures where you will see that Japan has 60,000 to 80,000 machines installed. Well what they are counting is a very simple air cylinder that moves in and goes back and forth

Under the U.S. definition, we only accepted reprogrammable machine that can move from job to job and isn't dedicated more to a process. So, when we break down what the real Japanese numbers say, we believe they have about 18,000 machines installed, which is still better than two times what we have.

They have been so good installing machines because they have taken the approach they want to keep it simple, and the majority of the 18,000 machines are fairly simple devices, two and three axis arms that go in and do fairly repetitive tasks. In the United States we have opted to go the more sophisticated route: the bigger computer, the more axes, and so on. We are just now learning that you don't need all that. As our user base, the manufacturing base, learns more about the technology, we will see a trend in this country to go simpler in the machines, and I think we will see a dramatic increase in the usage at that point.

Mr. BOEHLERT. Let me tell you, they are beating us in computer technology too.

Mr. BEDELL. Apparently, you do feel that they are putting much more effort into the computer technology?

Mr. WEISEL. Yes, I do.

I know Hitachi took 500 software and hardware engineers with the balance being very heavily slated toward software, and put them on robot projects alone, and said, "Here, these are the projects we are going to work on."

Mr. BOEHLERT. I would conclude by what you are saying there that not having information on what we are doing in terms of dollar volume that you really feel that it is insignificant and therefore inadequate.

Is that a fair statement?

Mr. WEISEL. I would say that is fair.

Mr. BOEHLERT. Do you have any comparison figures on robot error versus human error?

Mr. WEISEL. No, I would say——

Mr. BOEHLERT. Let me tell you what I am arriving at.

Mr. WEISEL. OK. I am not sure that I understand the question.

Mr. BOEHLERT. Oh, about 5 or 6 weeks ago, the New York Times Sunday business section had an outstanding article on the Toyota Co., and in that article it was pointed out that 85 percent of the automobiles coming off the Toyota assembly line are defect-free, whereas the average automobile coming off the American assembly line had 7 defects. Within that article, I seem to recall, there was some mention of robotics being used extensively in the automobile manufacturing, and then what you have told us, as you just did, that 10,000 robots displaced 300,000 American workers in the auto industry scares the hell out of me. It should scare everyone.

Mr. WEISEL. Yes.

Mr. BOEHLERT. So, that is why I am getting back to the human error versus the robot error.

Mr. WEISEL. I have toured the Japanese auto plants pretty well, and I would say that they have got their seven errors too; it is just that they are catching them farther down the line instead of the final count at the end, because they build in this, "Let's all get together and figure out where the errors are in stages."

Where they have automated it wasn't directed specifically at getting the quality up as much as getting the labor out.

You will go over there, and you will see the arms that are fairly simple arms that are just picking up engines from here and setting them down. Well our people have tended to laugh at that, and say, "Well, that is not a good robot job." We are still doing it with a

$30,000-a-year plus fringe labor, and they are doing it with a $10,000-a-year device that pays for itself overnight, and it works for 10 years.

So, when you go through it is actually kind of frightening to see how few people they have, but yet they have got them. They are all at the back end of the plant working on what they are going to automate next. The bodies are there, but the headcount is what goes against the product. The product cost is not down at the product line, it is back up in engineering.

Mr. **Boehlert**. Thank you very much.

Mr. **Bedell**. Thank you very much.

Mr. Bilirakis.

Mr. **Bilirakis**. Mr. Weisel, you are president of Prab Robots, Inc. In summary form, what does your firm do?

Mr. **Weisel**. We started in 1961 as a small manufacturer of metal scrap conveyors and scrap processing equipment, and we began in the robot business in 1969. Today we are probably 65 percent filtered dollar volume robots, and we have the second largest installed base in the country.

Mr. **Bilirakis**. Manufacturing robots?

Mr. **Weisel**. We manufacture robots, yes, sir.

Mr. **Bilirakis**. Are all of your robots manufactured at your plant?

Mr. **Weisel**. Yes, sir.

Mr. **Bilirakis**. By Americans?

Mr. **Weisel**. Right.

Mr. **Bilirakis**. Where do the component parts that go into making up that robot come from?

Mr. **Weisel**. They come from the United States. We have about 40 or 50 subassembly suppliers that supply equipment to us, and we have literally hundreds of component suppliers.

Mr. **Weisel**. We send our Prab robots out with an American flag on it, which says, "Made in America by Prab."

We have the United Steelworkers, so if you——

Mr. **Bilirakis**. So, would you say that is indicative of the industry in general, that all of the parts, all of the raw materials, and all of the component parts are made in America?

Mr. **Weisel**. I would say that the manufacturers who are manufacturing in the United States are using primarily U.S.-built equipment or parts. The thing that bothers me, and bothers a lot of the United States manufacturers is so many large United States corporations have rushed to Japan to bring in their equipment, and I think it is a big Trojan Horse.

I think the Japanese have established individual beachheads in large corporations to help get into the market; they don't make any bones about it. They want 25 percent of the industry by 1985 and they intend to dominate it until about 1990.

Mr. **Boehlert**. Would the gentleman yield?

I am supposed to be at another hearing at this same time. The Subcommittee on Science and Technology is dealing with the subject of strategic materials. Would strategic materials be involved in all your production, or is it generally the materials that are easily found and would not fall into the category of being strategic?

Mr. **Weisel**. Can you give me an example of what would be a strategic material?

Mr. **Boehlert**. Uranium.

Mr. **Weisel**. Oh, OK.

Now, we are adding the exotic materials.

Mr. **Boehlert**. Titanium?

Mr. **Weisel**. No.

Mr. **Boehlert**. Not domestically available?

Mr. **Weisel**. No, you might find a very few number of robots built each year that would go into nuclear applications where you need some exotic metals, but it is so small that it is less than 1 percent of what we are doing.

Mr. **Boehlert**. Just out of curiosity, how many people does your firm employ?

Mr. **Weisel**. We are at about 200.

Mr. **Boehlert**. Thank you.

Mr. **Bilirakis**. I have no further questions, Mr. Chairman.

Thank you, Mr. Weisel.

Mr. **Bedell**. Thank you.

Mr. Schaefer.

Mr. **Schaefer**. Have you done any cost analysis as far as insurance goes in replacing some of the more hazardous jobs with the use of robots or is there anything that has shown a drop in insurance costs due to the fact that we have fewer down time, loss time accidents on some of these areas?

Mr. **Weisel**. That is an excellent question, and we are unable to get a handle on the answers. Insurance companies know how to charge you because you may have a risk, but they don't know how to give discounts when you get rid of them. It is very difficult to get anyone to commit what that might be worth. We are learning what it is worth when you lose an arm, or if you lose a life because of our product liability situation. There is just no way in our accounting structure to take any of that into account. It is an overhead number that is there, and I don't think a plant that is fully automated has any less insurance premium than the plant that employs 100 workers.

Mr. **Schaefer**. But there still has to be fewer loss time accidents in some of these areas, and it would seem to me that would fall in line?

Mr. **Weisel**. Yes, it would.

Mr. **Schaefer**. With a dropoff in insurance.

Mr. **Weisel**. I know that among our membership, there are a number of robot manufacturers whose robots who have lost arms, and you could certainly equate those to actual lost human arms.

How we tie that back, I just don't have a good handle on that. Maybe that is something we ought to work on though.

Mr. **Bilirakis**. Would the gentleman yield for a moment?

Mr. **Schaefer**. Certainly.

Mr. **Bilirakis**. Mr. Weisel, you mentioned product liability. Has that part of the law extended to robots?

Mr. **Weisel**. Yes. Yes.

Mr. **Bilirakis**. At this point?

Mr. **Weisel**. Yes.

Mr. **Bilirakis**. It has?

Mr. WEISEL. Yes.

Mr. BILIRAKIS. In the sense that liability is going back to whom? To the manufacturer of the robot?

Mr. WEISEL. And the people that sold it, and the people that installed it, and the people that made the brochures? It is as widespread with us as it is everybody else.

Mr. BILIRAKIS. All right; thank you, sir.

Mr. SCHAEFER. No further questions.

Thank you.

Mr. WEISEL. I might add that the safety record of robots is really outstanding. We have never had a loss of life in this country.

There was a Japanese worker who lost his life, who jumped the hazard enclosure and got inside and was monkeying with the machine, tripped on one of the limit switches, and the robot pinned and killed him. But in general, the robot manufacturers are very cognizant of safety, and our trade association has a strong commitment with the safety committee that is setting standards at this point for installation.

Mr. SCHAEFER. Thank you.

Mr. BEDELL. Thank you.

One of the concerns that I think generally exists is the perception that the Japanese have moved ahead of us in terms of the automation of their automobile factories, for example, and that they now have a lead on the number of manhours required to produce an automobile compared to the U.S. facilities.

Do you see with the robot advancement and coming on that that gap is going to be closed between ourselves and the Japanese, or do you see it staying where it is, or do you see it widening? Apparently, they are going to be producing more robots than we are.

Mr. WEISEL. Right. I think it is going to be——

Mr. BEDELL. I am not just talking about automobiles; I am talking about our whole industrial fabric.

Mr. WEISEL. I believe it is going to close; and I believe they are working as hard at keeping it a widespread comparison, as we are trying to close it.

They have 140 manufacturers of robots, and they are starting to have a shakeout now. We have 30 to 35. Because of their downturn at this point, they have chosen the United States as the big market they want to get into.

Mr. BEDELL. You are talking about this big market of selling robots here?

Mr. WEISEL. Yes, sir.

I see the automotive industry moving very aggressively to try to catch up with implementation of robots. I see the textile industry moving very quickly to try and embody more robots, so I think one of the things that has happened is that the Japanese have been very gracious to us. They have opened their factories. They gladly host our tours, and we send vice presidents of manufacturing, and plant managers over, and we go through, and if they want to take in what they see, they come back with quite an education. They have learned that they have got to automate.

I was recently on a tour with about 40 U.S. executives who were all manufacturing people, and about a third of them walked out and said, "Well, that is not so tough; we could have done that 10 years ago."

Well, "could have done" is the kiss of death, and I think they are waking up.

Mr. BEDELL. You said the downturn? Are you indicating that in Japan the robot industry is finding that they can produce more than they can sell?

Mr. WEISEL. Yes.

Mr. BEDELL. You indicated that in Japan they are putting forth significantly more research effort on robot improvements, and you indicated further that in 1990 you thought we would have about 20 percent of the world robot market. How does that compare with the percentage we have today?

Mr. WEISEL. Today, the world dollar volume of robots shipped in 1981 was about $1 billion, and the U.S. market in 1981 was about $160 million, so we were about 15 or 16 percent.

Mr. BEDELL. About the same. Sc you think we would maintain about the same position?

Mr. WEISEL. I think so. I might add that one thing that is very important, particularly for small business is that in Japan, there is a national leasing program for robots. They have identified the robot as a key element in getting their productivity up and keeping their labor costs down, which helps exports of course. There are very low interest loans available to small business in Japan if they apply that toward robots or to other forms of automation.

The other thing is that there is a joint revenue share on R&D. I am not exactly positive of how it works. We can send a paper down on it. We have a writeup on what they do, where the Government will share in the funds that are required to put a robot on a new and untried application. So if they are plowing any new ground, the Government will back that with about a 50 percent credit of some kind. Also the robot in Japan has a faster depreciation schedule.

Mr. BEDELL. Their robots would depreciate somewhat more rapidly, would they not, because is it not true that ours are more complex, and therefore are easier to program for new tasks than theirs are?

Mr. WEISEL. Well, I think the depreciation schedule is set without an eye toward the complexity of what you are trying to depreciate. It is capital equipment, and it has got a fixed number of years.

Mr. BEDELL. Would it be easier to program them to do different jobs generally than it would Japanese robots, which tend to be simpler and for more single-purpose types of things?

Mr. WEISEL. Yes. That is true.

Mr. BEDELL. If there are no other questions, we appreciate very much your testimony.

Thank you for being here.

Mr. WEISEL. Thank you very much.

Mr. BEDELL. Our next witness is Marjory Blumenthal, who is Project Director in the Office of Technology Assessment.

We appreciate what OTA has done in helping us, and we look forward to your testimony, Marjory, and if you will also identify the person who is with you today for us.

TESTIMONY OF MARJORY S. BLUMENTHAL, PROJECT DIRECTOR, COMPUTERIZED MANUFACTURING AUTOMATION, OFFICE OF TECHNOLOGY ASSESSMENT, ACCOMPANIED BY FRED WEINGARTEN, MANAGER, COMMUNICATIONS AND INFORMATION TECHNOLOGIES PROGRAM, OFFICE OF TECHNOLOGY ASSESSMENT

Ms. BLUMENTHAL. Yes, with me today is Fred Weingarten, who is the manager of the communications and information technologies program at the Office of Technology Assessment.

I have submitted written testimony for the record, and I am prepared to provide a briefer oral statement today.

My written and oral testimony draw on the contents of the OTA technical memorandum published on March 18.

The full study, to be completed late this fall, will describe programable automation technologies and their development trends, discuss industrial structure and competitive conduct issues, and address a set of labor-related concerns, including potentials for employment change, likely change in the working environment, and implications for education and training.

Before addressing employment analysis issues, let me explain what we mean by computerized manufacturing automation, or programable automation. Those are umbrella terms that refer to a family of technologies used in manufacturing, including not just robots, but also computer-aided design and computer-aided manufacturing, computer-aided process planning, and a variety of automated materials handling, storage, and retrieval systems. We at OTA have not yet completed our own analyses of the potential employment impacts of programable automation.

However, our preliminary work included a review of how such analyses are typically made. We concluded from that review it is extremely difficult to evaluate how the expanding use of programable automation may affect employment.

Also, it does appear that many of the forecasts publicized in the business and popular press are unrealistic, and such pronouncements should be received warily. Most of the many publicized forecasts of programable automation employment impact appear to stem from one or two approaches, what we have called the "engineering approach" and the "economic approach."

There are often problems with the way both approaches are used.

The engineering approach for estimating employment impact involves describing what automation technologies can do, and comparing those capabilities with what people can do. While such analysis is needed to appraise employment impact, available forecasts suggest that one-to-one comparisons between people and machines are overemphasized. This can cause the potential for automation technologies to perform tasks that are never or poorly done by people to be overlooked.

Or, there may be a focus on technically ideal combinations of people and equipment which ignore the complex managerial considerations that shape observed employment patterns, and engineering estimates are easily confounded by errors in projecting technological capabilities.

Economic estimates of employment impacts rely on quantitative models of the workings of the economy. They explicitly account for many influences on employment, not just technology but prices, consumer preferences, labor supply trends and other factors. Because they are comprehensive, economic estimates are valuable for studying overall industry or national employment patterns. However, they are generally too aggregated for evaluating employment change at the company level.

Although economic estimates draw on engineering estimates, it is unclear how well they capture change in equipment technologies. Partly this is because they project future capital stock from past descriptions of industry's products and investments. It is also partly because adequate data on requirements for materials and on import levels, capital intensity, and other measures of how new technologies affect the economy are often not available. Another problem with economic estimates is the use of past staffing patterns or occupational profiles among industries to forecast employment. Again, this is a problem reflecting inadequate data.

Moving away from methodological issues, I would like to comment on how programable automation may affect employment.

First, it is important to recognize, as has already been said this morning, that programable automation is not new.

The technologies were first introduced in the late 1950's and early 1960's. However, the limited levels of use today suggest that significant employment change is not an immediate problem. Consequently, now is a good time to examine how these technologies may affect the work force.

Second, the employment effects of programable automation will stem from its distinctive attributes, including the following four:

First, there is the capacity for information processing, as well as physical work.

Second, there is the capacity for quality enhancement, which is reflected in various claims about the precision and the reliability of equipment and systems.

Third, there is reprogramability, which enables programable automation to be used to produce a diverse mix of products.

And fourth, there is the capacity for directly linking production and support equipment and systems.

These attributes will influence the costs, types, and amounts of products made with programable automation. They will also influence demand for automation products. These attributes explain why programable automation, unlike conventional automation, is likely to affect all types of employees, including managers, professionals and technical workers, as well as production workers.

Third, and finally, programable automation may affect employment by giving rise to changes in the organization and management of production. These changes may occur both within individual facilities, and between facilities, even between countries. Such organizational changes may shape the way that programable automation influences the working environment or the qualitative aspects of jobs.

We have not completed our evaluation of how programable automation may affect industrial organization.

However, we can make some tentative statements about the potential for these technologies to affect small businesses. Programable automation offers the potential for improving the competitive prospects of small businesses insofar as it is well suited for producing products in limited quantities, and it is cheaper to convert from producing one product to another, using programable as opposed to dedicated equipment and systems. Also, to the extent that producing programable automation emphasizes development of specialized software and applications engineering, activities that rely primarily on having good ideas rather than fixed investment, significant small business participation is possible.

To date, small businesses have been involved in supplying both relatively small and unsophisticated automation products, as well as relatively sophisticated and specialized automation products.

Finally, let me close with a few comments on education and training issues. In research to date, OTA has identified several education, training, and retraining programs relevant to the production and use of programable automation.

Such programs are sponsored by industry, labor organizations, public school systems, technical schools, community colleges, engineering programs, and CETA-funded programs. In addition, OTA sponsored a survey of 506 programable automation users, producers, and others familiar with instructional design and delivery.

Of potential user establishment surveyed, 40 percent did use some form of programable automation, but only 22 percent sponsored or conducted relevant education and training. In contrast, 93 percent of producer companies provided some instruction to their customers, primarily through single courses. Very few provided any graduated series of courses for their customers.

Many questions about appropriate curricula and targeting for instructional programs remain to be resolved.

Although the availability of such instruction is growing, current views of representatives from labor, industry, the educational community, and Government are consistent with other indicators in suggesting that training and retraining requirements for programable automation are at this point poorly defined.

Moreover, curriculum development, change, and delivery, are not proceeding in a coordinated fashion.

This concludes my oral presentation. I will be pleased to answer any questions.

Mr. **Bedell**. Thank you very much.

Mr. Bilirakis.

Mr. **Bilirakis**. No questions.

Mr. **Bedell**. Mr. Schaefer.

Mr. **Schaefer**. I have no questions.

Mr. **Bedell**. Thank you.

Ms. Blumenthal, if I understand your testimony correctly, you indicate that there is more to the change in automation than simply robots. There are other areas as well.

Is that correct?

Ms. **Blumenthal**. Yes.

We are looking at computer-aided design; computer-aided manufacturing; computer-aided process planning; automated materials handling, storage, and retrieval systems, and often these technologies are used in combination.

I think that when Mr. Weisel referred to the use of robots for loading and unloading of machine tools, that was one example of how different types of automation technologies may be used in combination.

Mr. **Bedell**. Now, are you looking at all those various aspects?

Ms. **Blumenthal**. Yes.

Mr. **Bedell**. Have you been able to do anything to determine the size of the work force replacement and where those people would be reemployed in the total picture, not just robots, but the total picture?

Ms. **Blumenthal**. We are trying to look at that, and we do not have any answers to those questions at this point.

Mr. **Bedell**. Do you expect to have those at some time in the future?

Ms. **Blumenthal**. We hope to; yes. We aim to complete our study late this fall, and at this point we are still gathering data and continuing with our analysis.

Mr. **Bedell**. And you hope that would include some indication?

Ms. **Blumenthal**. Yes, we hope to come up with ranges.

Mr. **Bedell**. We are talking about something that is going to increase jobs or decrease jobs, or leave them the same?

Ms. **Blumenthal**. Well, I think that as we——

Mr. **Bedell**. Total labor really, rather than jobs.

Ms. **Blumenthal**. From what we have seen already there is a difference between job displacement and unemployment, and they don't necessarily correspond to each other, one to one.

For example, drawing on Mr. Weisel's example, there are cases where machine operators were displaced, but they had new jobs as inspectors or packagers.

So in a way that operator's job has disappeared, but there is a new job into which an existing individual has moved, and that individual has not become unemployed.

Mr. **Bedell**. So, you will be looking at that?

Ms. **Blumenthal**. Right.

We expect, given displacement that may occur, some—but certainly not all—people may shift into new jobs, either within their companies or elsewhere, without people being involuntarily unemployed. However, there is also a question about what happens to people who would have had the jobs that might have been created; and that is the part that is a little bit harder to analyze.

Mr. **Bedell**. For all of history, we have been moving where it really requires fewer man hours or work hours to produce any product. I think we have seen that. It is my impression that we are moving much more rapidly in that direction today than we have in the past.

Ms. **Blumenthal**. In terms of the actual production work, certainly the technologies that we are looking at or other trends are reducing the production labor input.

However, although some of these trends are also reducing the white collar elements, it also seems to be the case that additional sources of that kind of job, of engineering jobs, managerial jobs, sales jobs, and so forth may be created.

I think Mr. Weisel gave an indication of how 350,000-400,000 new jobs would be created. He listed primarily what we call white collar jobs: sales, R&D, applications engineering, and so forth. To the extent that the use of these technologies requires a lot of planning, certainly there is going to be a significant labor component for conceptual work.

Mr. **Bedell.** You do indicate that apparently a robot itself is a junior member of programed automation. Is that correct?

Ms. **Blumenthal.** It depends on what you mean by junior. Certainly, the technology has been around for a long time, but actual usage in this country is relatively low; and in that sense I guess you could say it is——

Mr. **Bedell.** There are other areas that are moving at least equally as rapidly, in terms of automation?

Ms. **Blumenthal.** Right.

Mr. **Bedell.** What would you guess the rate at which various aspects of the programmable automation will come? Would you agree with the testimony as to how many robots we can probably expect by 1990?

Ms. **Blumenthal.** Those estimates are in the ball park with other estimates we have seen.

Typically, when I see forecasts on robots used, and on, for example, computer-aided design use, people rely on growth rates of somewhere in the vicinity of 35 percent or more a year, in growth.

Of course, you must remember, that growth is on a somewhat small base, for even with a large growth rate, you don't necessarily end up with a large base of use until after a certain period of time has passed, but those numbers that were given before are consistent with other numbers that I have seen.

Mr. **Bedell.** Do you think that CAD will pretty well eliminate draftsmen?

Ms. **Blumenthal.** Well, in your earlier remarks, you referred to how the past use of tools extended people, and how robots, for example, may displace people.

Well, CAD systems seem to be more likely to extend the work of their operators than robots, because you still need to have someone working at that terminal to do design work.

You may replace a separate draftsman who was a support person to an individual doing design. In other words, without CAD, a designer came up with an idea, and someone else drew the picture; with CAD, you may combine the drawing with the conceptual aspects. The work of the designer may be extended, or enhanced while the work of the draftsman may be displaced.

I think that most people who have looked at the problem do expect displacement of draftsmen.

Mr. **Bedell.** Thank you very much for your testimony.

[Ms. Blumenthal's prepared statement follows:]

PREPARED STATEMENT OF MARJORY S. BLUMENTHAL, PROJECT DIRECTOR, COMPUTERIZED MANUFACTURING AUTOMATION, OFFICE OF TECHNOLOGY ASSESSMENT

Good morning. My name is Marjory Blumenthal; I am the Project Director for the assessment entitled Computerized Manufacturing Automation: Employment, Education, and the Workplace at the Office of Technology Assessment. With me today is Rick Weingarten, Manager of the Communications and Information Technologies Program.

My remarks today are based on the contents of an OTA Technical Memorandum entitled Automation and the Workplace: Selected Labor, Education, and Training Issues. This technical memorandum, published in March, is the first product of the ongoing assessment just mentioned. The assessment itself was requested by the Joint Economic Committee, together with the Senate Committees on Labor and Human Resources and Commerce, Science, and Transportation, and the Subcommittee on Labor Standards of the House Committee on Education and Labor. It will be completed this Fall.

Computerized manufacturing--or, more simply, programmable automation--is an umbrella term that applies to several types of automated equipment and systems that draw on computers, including robots, computer-aided design or CAD, computer-aided manufacturing or CAM, computer-aided process planning or CAPP, and automated materials handling, storage, and retrieval systems. While robots seem to attract most of the attention of the media and other public commentators, they are only one component of a larger set of programmable automated technologies. It is also important to recognize that programmable automation technologies are not new. For example, the beginnings of CAM may be found in the development of numerically-controlled machine tools in the mid-1950s, while industrial robots were introduced in the early 1960s.

In spite of this early introduction, current use of programmable automation in the United States is limited. The Robot Institute of America, for example, reported that fewer than 5,000 robots were believed to be in use in the United States in 1981--only a few tenths of a percent of the 2.6 million machine tools reported by the National Machine Tool Builders' Association to be in use in U.S. metalworking industries alone by the late 1970s. Also, of that stock of machine tools, fewer than 4% were believed to be numerically controlled. Thus, even with the expected increase in the rate of introduction of programmable automation in manufacturing increases, any major impacts of programmable automation on total employment and on education and training needs are likely to be felt in the future. The most immediate impacts may be experienced in industries such as transportation equipment, industrial machinery, and electronics, which have been the first to adopt programmable automation. (An August 1982 OTA survey of establishments in those industries revealed that 40% of respondents used some form of programmable automation.)

At this point in our study, we are unable to provide independent information on the magnitude and timing of any such impacts. OTA's recent

Technical Memorandum does, however, discuss procedures for projecting potential employment change associated with programmable automation. While we have not critically evaluated specific projection attempts, we examined general methodlogical issues to help us decide on our own approach. The Technical Memorandum also touches on some working environment issues, and it describes the nature and modes of delivery of education and training for persons holding or seeking jobs in manufacturing industries. These issues, gauging possible shifts in skill requirements and resulting instructional needs, are proper concerns now since substantial lead times are required for developing instructional programs.

Four attributes of programmable automation are key to understanding their ramifications for the labor force: (1) capacity for information processing as well as physical work; (2) capacity for enhancing product quality; (3) reprogrammability, enabling their application to the production of a diverse mix of products; and (4) capacity for linking production equipment and activities. These attributes will influence the types of products that can be produced with programmable automation and their costs. Moreover, these attributes will influence (1) the types and range of human activities that can be replaced by machines; (2) the types of new applications providing work for both people and machines; (3) the types of skills required to produce and work with programmable automation; and (4) the organization and management of manufacturing processes. It is through such influences on the role of labor in manufacturing that programmable automation may give rise to changes in the numbers and types of people employed, and therefore changes in requirements for education, training, and retraining.

How, when, and where programmable automation affects employment and training requirements cannot be confidently predicted, and are even hard to project in detail, for three reasons: First, the design and implementation of programmable automated equipment and systems vary widely among users. From a technical standpoint, programmable automation comprises a set of equipment and systems technologies that can be used interchangeably, to some extent; in different combinations; and in combination with conventional equipment and systems. The impact on labor, however, may be quite different from one system to another.

Second, the extent to which programmable automation will be used is itself subject to uncertainty. It will depend on: (a) the rate of technological change (in particular, the rate at which automation innovations are commercialized); (b) the nature of the technological change (programmable automation, for example, changes production processes through the use of new equipment but it may also be associated with new management practices, which themselves are a form of new technology); and (c) the pattern of technology diffusion (although programmable automation is currently concentrated in metalworking and electronics industries, whether and when it spreads to other industries influences the mix of employment opportunities of current and prospective members of the labor force.) These factors complement and influence change in product demand, which also affects the extent of use of programmable automation. To complicate matters more, all three factors will be affected by actions and conditions in other countries that produce and use programmable automation.

Third, the traits and behavior of the labor force influence whether changes in the workplace and the role of labor in manufacturing translate into unemployment. For example, the impact of labor-saving technologies varies with the rate of growth of the population, and with the willingness and ability of people to hold different types of jobs.

In short, evaluating the effects of increased use of programmable automation on employment is extremely difficult. Consequently, statements about the future labor impacts of programmable automation, especially on a national level, should be received warily and their underlying assumptions fully explored.

Future Labor Markets. Since many predictions of labor impacts are being made, I would like to discuss some of the methods used to generate estimates of future occupational employment. Historically, attempts to forecast detailed changes in occupational employment have met with limited success. OTA reviews the ways in which occupational forecasts are made, and provides general comments and criticisms in the technical memorandum. OTA has not found any methodology which is satisfactory in all aspects.

Publicized estimates of employment change associated with programmable automation appear to derive from two approaches, one an engineering-oriented approach, and one an economics-oriented approach. I will briefly review those approaches and some of their characteristics.

Engineering estimates are based more or less exclusively on technical aspects of technological change. They are made by describing the capabilities of new automation technologies, projecting improvements over time, comparing equipment and system capabilities to tasks performed by humans, relating human tasks to different occupations, and deriving the number of jobs, by occupation, that could be assumed by new and future versions of automated equipment and systems. A similar approach can be used to derive the number of jobs required to produce automated equipment and systems.

The engineering approach is easily understood, and it is a useful first step in estimating potential employment impacts of programmable automation. However, it is subject to the following problems: First, these estimates are easily confounded by errors in projecting future technological capabilities. Second, because they rely on point-by-point comparisons of electronic and mechanical capabilities with human capabilities, the potential for automated equipment and systems to either perform jobs in ways other than simulation of human behavior, or to perform jobs that are poorly done or not done at all by humans, may be missed. This failure may result in over- or under-estimation of job displacement.

Third, the result of an engineering analysis is typically a "technically" ideal mix of humans and equipment, while the actual mix may reflect complex management and implementation considerations. Finally, engineering-based estimates of job displacement frequently assume that labor force characteristics remain constant, another source of potential bias.

Economic estimates are made by explicitly evaluating several factors, in addition to technology, that impinge on employment demands, such as prices and production levels. They rely on engineering analyses for descriptions of the effects of technologies on industry's requirements for inputs to production, including labor. The most detailed economic estimates of employment change come from models that include input-output components. Projections by the Bureau of Labor Statistics, for example, are made by combining an input-output model with other models that forecast change in the labor force and in the level and pattern of economic activity, and with descriptions of industry staffing patterns.

Economic estimates are inherently more comprehensive than engineering estimates because they rely on macroeconomic models. Macroeconomic models are comprised of mathematical equations that describe how an economy uses its resources to produce and consume goods and services. This framework prevents overattributing employment changes to single influences such as technology change. On the other hand, their high level of aggregation renders them impractical for gauging possible employment change at the company level. Also, the use of large-scale models carries the risk of oversimplifying complex processes and conveying an impression of greater analytical thoroughness than may actually exist.

Other shortcomings of economic estimates include the following: First, economic models that project labor supply and industrial output separately may not capture the complex interactions of demographic and economic factors that influence the growth of the labor force and change in labor force participation by different groups within the population. Nor may they capture differences in the quality of the labor force, differences which may govern the ability of the labor force to adapt to changes in economic activity.

Second, economic models tend to project future capital stock by extrapolating from past conditions and future staffing patterns by reflecting past or current practices. In doing so, they may miss some important changes in equipment technologies as well as changes in the organization of production and management that may accompany new technology.

In sum, the OTA review of occupational employment projection practices suggests, at this time, that satisfactory projections should take into account several factors that contribute to the direct and indirect effects of programmable automation.

Working Environment. Programmable automation may change not only the numbers and types of people working in manufacturing, but also the circumstances of work--what may be called the working environment. We have only begun to examine this set of issues, but we are struck by its importance. How programmable automation affects the working environment will depend on how it is applied. Changes in the working environment may be experienced in many ways. For example, occupational safety and health risks may change, as automated metalworking tasks may reduce occupational hazards, while increasing use of video display terminals might create new types of problems. Also, the introduction of programmable automation may lead to changes in job content, including task variety and degree of mental challenge.

Education and Training. Because it may alter the demand for different types of employees and the nature of different jobs, the increased application of programmable automation in manufacturing can trigger widespread changes in education and training requirements. Programmable automation may thereby augment the effects other technologies have on the U.S. economy and its instructional needs, which were documented in a recent OTA study entitled Informational Technology and its Impact on American Education. The utilization of programmable automation, depending upon its impact on employment levels within specific occupations, may not only alter instructional requirements for people holding or seeking jobs in the manufacturing sector, but it may also necessitate the retraining of individuals for occupations in other sectors.

As new technologies, such as programmable automation, begin to affect the economy, individuals, industry and labor organizations respond by seeking out (and providing) education and training. We do not know, however, how much of this education and training is sought or provided as a means of adapting to programmable automation or changing manufacturing technology in general. (Overall, we do know that professional and technical employees, and people between the ages of 17 and 35, tend to participate in education and training more than other groups. This is noteworthy because other groups in the labor force, such as older semi-skilled and skilled production line workers, may be at great risk when programmable automation is introduced in their facilities.)

Private industry is a major provider of instruction. The American Society for Training and Development estimates that U.S. industry now spends approximately $40 billion annually on education and training programs for employees. They and other sources also estimate that technical instruction beyond apprenticeship is infrequently offered by companies to employees other than engineers and data processing personnel. This appears to be due to the relatively high cost, equipment requirements, and stringent instructor qualifications associated with such instruction. In smaller firms, little or no technical or skills-related instruction is offered. These firms traditionally rely on on-the-job training, which is less expensive than formal instructional programs.

Labor organizations are also involved in instruction, but usually not as providers. Since the 1960's, labor unions representing manufacturing workers have taken a growing interest in securing education and training benefits for their members through the collective bargaining process, reflecting an awareness of the potential impacts of technology on their members. The United Auto Workers and the International Association of Machinists are among the most active unions in promoting technology-related education and training opportunities for their respective memberships. For example, 1982 agreements that the United Auto Workers reached with Ford Motor Company, General Motors and International Harvester contain provisions for training and retraining current employees as well as those laid off. In addition, each contract calls for the establishment of a joint union-management employee development and training committee through which special instructional assistance will be provided to members who are displaced by new technologies, new techniques of production and "shifts in customer preference." Employees both skilled and semiskilled are covered under other provisions of the agreements and are eligible to participate in upgrade training designed to sharpen job skills and to familiarize them with the state-of-the-art of technology being utilized in their plants.

The International Association of Machinists has developed model contract language for its locals that includes provisions for dealing with in-plant technological change. The language on training benefits, for example, calls for instruction during working hours at company expense and at prevailing wage rates. Model contract provisions also state that senior employees should have first claim on training opportunities. Other provisions pertain to training for jobs not necessarily associated with new technology, in cases where "...either the new technology requires substantially fewer workers or present employees are not capable of successful retraining."

Of course, labor organizations and industry are not the only parties involved in educating the labor force and in altering instruction in response to new technology in general and programmable automation in particular. In research performed to date, OTA also has identified several public school systems, technical schools, community colleges, engineering programs and CETA-funded programs that provide instruction for programmable automation.

In order to identify the state-of-the-art of instruction for new manufacturing technology, OTA sponsored a survey of representatives of companies that produce programmable automation equipment and systems, companies that do or may utilize programmable automation, as well as labor unions, traditional and nontraditonal educational institutions, and others familiar with instructional design and delivery. Findings from 506 interviews indicate that although 40 percent of the manufacturing plants surveyed used some form of programmable automation, only 22 percent sponsored or conducted education and training for the new technology. Among plants currently not offering education and training programs of this type, only 18 percent indicated any plans to implement programs in the future.

In contrast to the low proportion of firms applying the technology in their manufacturing facilities who also sponsored and conducted training for new technology, 93 percent of the companies who produce automated equipment and systems provide some form of instruction for their customers. The nature and scope of the instruction these firms offer is quite limited. Over 80 percent provide only single courses and very few provide any sort of graduated series of courses. Furthermore, only about a third of these companies indicated that they were currently ready to provide all instruction they felt necessary for production line employees.

Because programmable automation is only now presenting the prospect of major employment and training changes, many questions about appropriate curricula and targeting for instructional programs remain to be resolved. Although the availability of such instruction is growing, current views of representatives from industry, labor, the educational community and government are consistent with other indicators in suggesting that training and retraining requirements for programmable automation are, at this point, poorly defined. Even within specific geographic areas, programs initiated to address changing instructional requirements do not, in the aggregate, represent a coordinated approach to defining instructional needs associated with new industrial processes.

While it is too soon to know how widespread the applications of programmable automation will be, there is little evidence that any group--including private industry--is seriously considering the long-range implications for occupational skills requirements and instructional capacities of growth in the production and use of programmable automation. Among the pressing issues facing those who provide instruction, in response to the spread of programmable automation, are:

1. how and by whom the need for technological literacy will be addressed;
2. the types of short-term and long-range counseling and instructional systems needed;
3. the initiation of appropriate curriculum design processes; and
4. funding sources for curriculum design and implementation, including equipment.

In conclusion, Mr. Chairman, the points that we would like to stress now are the following: First, robots are but one component of a larger programmable automation phenomenon. Second, specific--that is, occupational and industrial--employment impacts are hard to predict, and we lack confidence in those predictions currently publicized. Third, changes in the numbers of jobs are only a part of the consequences of automation, another important part being changes in the quality of jobs. Fourth and finally, while new instructional programs for persons who may use or produce programmable automation are emerging from several sources, curriculum development, change, and delivery are not proceeding in a coordinated fashion.

Mr. BEDELL. Our next witness is Allan Hunt.

Mr. Hunt, we appreciate you being here, and we appreciate the commitment that Upjohn Institute has to matters of public policy. We appreciate the work that you have done in Michigan, and certainly, they have got their problems.

Mr. HUNT. Yes, we do.

Mr. BEDELL. And we are most anxious to hear you.

TESTIMONY OF H. ALLAN HUNT, ACTING MANAGER OF RESEARCH, W. E. UPJOHN INSTITUTE FOR EMPLOYMENT RESEARCH

Mr. HUNT. Thank you, Mr. Chairman.

My name is Allan Hunt, and I am acting manager of research at the Upjohn Institute for Employment Research in Kalamazoo, Mich. For those who are not familiar with the work which we do—and I am happy to see that it does not include Congressman Bedell—we are an endowed nonprofit research agency that has been dedicated to research and publication on the general issues of employment and unemployment since 1945. I am sorry to have to report that we haven't solved all the problems. Maybe we haven't solved any of them yet, but we are doing our best.

We have just completed a project on the employment implications of robotics. It was initiated at the request of the Michigan Occupational Information Coordinating Committee, which is the State agency in Michigan responsible for providing guidance for educational planning, career decisions, et cetera.

It reflected the keen interest that the State of Michigan has in robotics. Both because the State of Michigan, with the auto industry, is the No. 1 target for robot sales these days, and second because the State of Michigan has undertaken to secure a greater share of American manufacturing capacity in robots. Therefore we were interested in both sides of the story, that is job displacement impacts on Michigan's economy, and job creation potential of Michigan's economy. My colleague, Timothy Hunt, and I have spent the last 13 months examining these employment impacts, and we have just published a book containing those findings.

I want to say that ours is a relatively narrow study. That is to say, we only concerned ourselves with robotics, and there is a good reason for that. The Michigan Occupational Information Coordinating Committee wanted specific results, and specific answers. They wanted to know what kind of people, with what kinds of skills would be displaced, and what kinds of people would be required to fill the new jobs that would be created. So in an attempt to fulfil that need, we tried to define the study narrowly in its scope. In reference to Ms. Blumenthal's remarks, the OTA study has much greater scope than ours, and will correspondingly have a higher payoff in a policy sense, I hope.

But we believe on the basis of our work that we have seen enough to know that the high-tech hype that we are experiencing almost on a daily basis from all the media is misplaced. Robots are coming; they are coming rapidly. They are not coming tomorrow or even the day after tomorrow. We are talking about a robot forecast that corresponds with what Mr. Weisel said. We forecast a U.S.

robot population ranging from 50,000 to 100,000 in the year 1990. That makes a growth rate of 30 to 40 percent annually as Ms. Blumenthal referenced. We are in agreement with that.

Our forecast is based upon a number of assumptions about the economy and about specific applications of robots, which I will go into, but I am not going to address them right now.

The critical thing about robots is that they represent process technology, and not product technology; that means that the rate of change is much less than we find in consumer goods.

Robots are not an Atari revolution. In fact, I would take exception to your opening statement, Mr. Chairman. Robots are labor displacing technology in the same way that every other piece of machinery is that we have used. Robots seem different because of microprocessor control, which has some fancy implications, but it is not fundamentally different. The impact of robots will be evolutionary, not revolutionary. We think we have every chance to manage this change effectively.

I would like to impress upon you the parallel concern expressed in this hearing and in the media in general, to the situation that we had 20 years ago, when we had our first—at least in my professional lifetime—automation scare.

We had a halting recovery from two recessions in succession. We were unhappy with the employment performance of the economy as a whole. Many turned to automation as the cause for that, in the person of electronic data processing, otherwise known then as digital computers. We appointed a National Commission to look into this. In the meantime, we also made some gains on the employment front by the 1964 tax cut and other measures, and the problem went away by the time the National Commission had completed its deliberation.

Robots will eliminate jobs. They are a labor-saving technology. We are not convinced that this is a fundamental change in the rate of application of technology or in the rate of displacement of people from jobs. I want to make a very clear distinction between the displacement of jobs and the unemployment of people. I will come back to that in a moment. I provided in my prepared remarks some tables showing the direct job displacement impact up to 1990, consistent with our robot population forecast. Overall, those results show that we expect less than 1 percent of current jobs will be eliminated in manufacturing by robots between now and 1990.

Somewhere between 1 and 2 percent of production worker jobs will be eliminated in that same timeframe. Overall, I would say those are insignificant impacts. However, there are some places where I would not say that. In particular, in the auto industry which is very aggressively robotizing we think the implications of the auto industry plans are that somewhere in the neighborhood of 6 to 11 percent of production worker jobs in the auto industry will be eliminated by 1990. Now, I want to be careful in the way that I say this. That is not a forecast, per se, of the employment in that industry. It is an attempt to assess the impact of this technology on the job base that exists there. It does not include, for instance, a separate forecast of economic recovery, a separate forecast of the success in repelling the Japanese invasion of the auto industry, et cetera.

In particular in applications like painting and spot welding, we see very dramatic labor displacement, job displacement impact: Up to 40 percent of production painters in the auto industry, for instance, and something on the order of 20 percent of welder jobs. Frankly, the reason the welder number is not higher reflects the small firms, the supplier firms to the auto industry, which use a lot of welders also, and which we do not anticipate moving to robots at the same rate as the large firms.

The unemployment impact of this is not going to be massive. I am talking now about throwing people out of work. We are convinced by examining the data that are available, that in a narrow sense, this kind of job displacement can be handled by normal attrition rates.

We are using the BLS data estimating how many workers will be needed for replacement purposes, given the average age of workers in a particular occupation in the labor force, et cetera. We are talking about eliminating 1 job in 10 for replacement needs for production workers. That is not zero, but it is also not 10 in 10, or 9 in 10. We are encouraged in terms of the current work force. In the auto industry, to choose an example with which I am more familiar, the General Motors-UAW contract of 1982 provides a rather large commitment to retraining. There is a $40 million annual pool for a quality-of-work life and environment enhancement, and productivity enhancement efforts. There is also an $80 million annual commitment for upgrading the current work force. Displaced workers, therefore, will not be a major problem. I think that problem has already passed its peak. What we obviously have is an economic problem, a cyclical problem, to which the media has generally overreacted by ascribing our problems to other causes.

Where the unemployment impact will be felt, I fear, is among our youth, in the jobs that are not created because of robotics technology and other productivity improvements. I would reference the New York Times article of yesterday where it was mentioned that some large firms avowed that they intend to increase their production levels in line with their recovery from recession, but without adding additional workers.

I have been afraid of that statement hitting the newspapers for some time. I think that is probably the plan that will generally be adopted. I don't think it is going to happen in the auto industry, because I am hopeful that the recovery is going to come faster than they can implement the robotics. But nevertheless, those are the kinds of future scenarios I think we can anticipate.

I do want to say that I would make one exception of the displaced worker, and that is in the plant closing situation. I think that is where we should look for the truly displaced worker, if we mean people who have permanently lost a connection with their previous employer. I think this problem needs to be addressed, and I am hopeful that the new provisions under JTPA will move in that direction.

For job creation, in contrast to our overall displacement of up to 200,000 workers by robotics, we see the direct creation of somewhere between 32,000 and 64,000 jobs by 1990. Again, in the narrow sense, this does not include price impacts, et cetera. It is an engineering study, as Marjory Blumenthal put it earlier, not based on a specific economic model.

What we think is significant about the job creation is not the fact that three jobs are eliminated for every job created, because we don't endorse that kind of deduction. What we think is significant is that the jobs that are created are very different from the jobs that are being eliminated. We have labeled this the skill twist. It is a significant development, and we think that it has a much broader application than just to robotics.

The jobs that are being eliminated by robotics and by other automation tend to be the semiskilled jobs, the muscle jobs. The jobs that are created are technical, scientific-based, white-collar jobs which require significant skills, not just narrow job skills training, but a broader general skills training.

The biggest occupational group to be created is the robotics technicians, by which we refer to people who are able to troubleshoot, install, repair, essentially attend to the care and the feeding of the robots in the industrial environment. We forecast up to 25,000 jobs for robotics technicians in this decade. We think this is going to be a mix of community college trained people, that is 2-year graduates, and retrained workers, particularly in industries like the auto industry where this kind of commitment can be made and has been made.

The second largest group is the graduate engineer area. We have forecast up to 9,000 jobs in robotics created for graduate engineers. We think this is an immediate problem, because we don't see where those engineers are going to come from. Assuming recovery from the recession, we already have a shortage of engineering talent in this Nation, and we think that has some possibility of compromising the expansion of robots, as Mr. Weisel said earlier.

In my opinion—and I would be happy to respond to questions—I don't think that the new technology represents more bad news in the sense that it is being treated in the media. I think we are overreacting to cyclical problems, and I will say that I am confident that more jobs will be created, at least in the State of Michigan, in the next decade by recovery from the recession than will be created by all the high-tech areas together. That reflects some structural problems in the State of Michigan and heavy dependence on consumer durable industries, as you know. But it also represents my judgment as to the overall potential of high tech. I cannot testify to this directly, but I would call your attention to the forecast that DRI developed for Business Week predicting somewhere between 730,000 and 1 million high-tech jobs nationwide in the next decade.

I am comfortable with that number in terms of what we are talking about, and that is one of the reasons why I use the term "high-tech hysteria." I don't want to say we turn our backs on it. We have got to be involved, but the payoff to the high-tech stuff is 20 years down the road, not 2 years down the road. It is important to understand that, so we don't lose sight of what our current problems are.

Let me say that I think the major problem is the same problem that we have had for the last 20 years—oversupply of unskilled labor. That results in a general way from automation, from international economic development, and other factors. All those things are no doubt true; still the problem is clear, at least to me.

My solution is to stop adding to that problem, that is to stop adding to the unskilled labor supply in the labor market. In a demographic sense let me just say that we are going to get some help. I am sure that Mr. Kutscher is going to testify to this tomorrow.

The teenage labor force is going to start declining in annual additions, at least. We have had these enormous increases over the last 20 years in our labor force. Overall, the job creation aspect of economic performance has not been that bad; but since the labor force increased more rapidly, we have had rising unemployment.

The worst part of that is behind us. We now have an opportunity to try and digest some of that increase in the labor force that we have experienced. I think we need better basic education, and I am talking science, technology, math, et cetera. I think it is a shame that we continue to turn out functional illiterates from our general high school population. I think we need to move on that front, and I can, without having read the full report, find myself in sympathy with the Commission on Excellence that recently released their report.

I think we need tax incentives for human capital formation that parallel those on the physical capital side. Taking cognizance of the fact there are public subsidies already for educational efforts, I think, we need to signal to the private sector, both firms and individuals that we are interested in their investment in their own human capital. This means tax credits, tax deductions, and so on.

It seems to me folly to continue to say that if you invest in your own human capital, for minimal preparation for your occupation, that is tax deductible. If you are attempting to improve your human capital to qualify for a better job, that has never made sense to me.

Last, I want to mention that I think that we need to continue to improve our efforts in occupational information: labor market information and career guidance. I think Mr. Kutscher of the BLS will address this tomorrow. I will render a helping hand to the Bureau of Labor Statistics, and at least avow that they are getting beat up unfairly, to some degree. They have not had the data base in the past. Decennial census data is simply not adequate to interpret trends in occupational demands.

The new 3-year occupational employment statistics survey (OES) promises much more in that regard, but those data are only beginning to become available. We need to improve that effort and fund that effort at a reasonable level, and improve the analysis of it, so that it gets out on a timely basis.

Our human resources system in the United States has always been decentralized and unplanned.

That has served us well over the years. I don't think it is time to scrap that system and go to a European system of quotas and training for specific jobs; but we need to provide decisionmakers with good information on which to build.

Thank you for your attention. I would be happy to respond to questions.

Mr. BEDELL. Thank you very much.

[Mr. Hunt's prepared statement, with attachments, follows:]

PREPARED STATEMENT OF H. ALLAN HUNT, ACTING MANAGER OF RESEARCH, W. E. UPJOHN INSTITUTE FOR EMPLOYMENT RESEARCH

My name is Allan Hunt. I am Acting Manager of Research at the W. E. Upjohn Institute for Employment Research in Kalamazoo, Michigan. The Upjohn Institute is an endowed, nonprofit organization that has been engaged in conducting and publishing policy-oriented research in the broad areas of employment and unemployment since 1945.

We have just completed a project on the employment implications of robotics. It was initiated at the request of the Michigan Occupational Information Coordinating Committee and reflected the keen interest within the State of Michigan in robots and their employment impacts. My colleague Timothy Hunt and I spent the last 13 months examining the employment impacts of robotics and have just published a book relating the results of that research. I will be drawing freely from this volume in my testimony today.

What is the essence of our findings? We believe the robots are coming; not as rapidly as anticipated by some nor with the devastating impact predicted by others, but they are coming. Furthermore, we all have a stake in the impending change, at least to the extent that robots will be part of a movement to raise the productivity of American factories and retain the competitiveness of American goods on national and international markets. We argue that robots should be regarded simply as another labor-saving technology, one more step in a process that has been going on for some 200 years.

Before proceeding it is necessary to put the so-called "robotics revolution" into some perspective. There are precious little hard data about industrial robots today. Most of the public awareness of robots has been shaped by the hyperbole in the popular press. Futurists and others compete for media attention with wild projections of the impacts of robotics--800,000 people making robots, 1.5 million technicians maintaining robots, and millions of workers displaced--with little or no consideration of the practical issues involved. We believe the intense media attention on robotics in the past year or so has seriously confused the issues.

First, we submit that the very use of the word "revolution" is inappropriate when dealing with any manufacturing process technology. Capital goods for production have long lives and are not scrapped immediately when something better comes along. Numerically controlled machine tools, usually regarded as the capital equipment most closely related to robots, expanded at a growth rate of only 12 percent for the most recent ten-year period. After 25 years, only 3 to 4 percent of all metalcutting machine tools are numerically controlled. Even digital computers, widely heralded as the most significant technological innovation of the 1960s and 1970s, expanded at a growth rate of only 25 percent (excluding microcomputers for home market). Yet many are implicitly assuming much higher growth rates for industrial robots. In terms of actual application, process technology changes tend to be evolutionary rather than revolutionary because of the physical, financial and human constraints on the rate of change of process technology.

Second, the fear of massive unemployment caused by the introduction of industrial machinery appears to be unfounded historically. Such fears began with the dawn of the industrial era in the 1700s. They are particularly acute during major recessions. For example, the "automation" problem was of urgent national concern in the early 1960s after a halting recovery from the sharp recession of 1958-59. There were grim predictions that automation was causing permanent unemployment in the auto industry and other industries. A national commission was appointed to study the problem and in 1966, with the economy near full employment, the commission rendered its final report. They concluded that a sluggish economy was the major cause of unemployment rather than automation.

Third, there appears to be a fundamental lack of understanding that the association of technological change, economic growth, and job displacement is not just a coincidence; they are intertwined and inseparable. That is not to imply that adoption of new technologies necessarily insures economic growth, or that displaced workers will always find new jobs. However, it does mean that we all have a vital stake in productivity gains (i.e., in displacing jobs) because that is what allows the possibility of rising real incomes. The price of a growing, dynamic economy that makes more goods and services available to all of us is job displacement, or the elimination of jobs through technological change.

In our book we assess the direct impact of robots on the employment picture in the U.S. and Michigan between now and 1990. Our data were gathered from published sources and through interviews with robot manufacturers, robot users, and other experts. Still, it was necessary to resort to considerable projection and estimation. This creates the opportunity to be extravagant, but we tried to avoid this. We selected the conservative, but realistic alternative wherever there was a choice. All judgments and assumptions are explicitly stated in the full monograph. Due to the space limitations here, however, the emphasis is on conclusions rather than methodology.

U.S. Robot Population

The projections of occupational impact in our research are the result of first forecasting the U.S. robot population by industry and application areas. This approach constrains the employment impacts to reflect the actual expected sales of robots. In this way a consistent economic framework is established within which it is possible to estimate not only the population of robots and job displacement but also the job creation resulting therefrom. This consistency is also very helpful in avoiding unrealistic or exaggerated conclusions. Table 1 shows our robot population forecast for 1990.

We expect strong growth in the utilization of industrial robots in the decade of the 1980s. We forecast that the total robot population in the U.S. by 1990 will range from a minimum of 50,000 to a maximum of 100,000 units. Given our estimate of the year-end 1982 population of approximately 7,000 units, that implies an average annual growth rate of between 30 and 40 percent for the eight years of the forecast period, or roughly a seven to fourteenfold increase in the total population of robots. As shown in Table 2, our forecast tends to be on the conservative side compared to other published estimates. However, the upper end of our range is generally consistent with other forecasts.

Our projected range is intended to contain the actual robot population with a high probability level, and allows for variation in interest rates, capital investment climate, auto industry recovery, and rate of economic growth. We are confident this range will contain the 1990 robot population. That means we do not expect developments such as the total collapse of the automobile industry, a major renaissance in U.S. capital investment, the early development of a significant number of nonmanufacturing robot applications, or the widespread adoption of robotics technology by small firms.

The U.S. population of robots is developed separately for the auto industry and all other manufacturing. This is partly to take advantage of the fact that the auto producers have announced goals for robot installations which could be factored into our robot population forecast. It also reflects the fact that the major impact of robots in the State of Michigan will be in the auto industry. Our forecast sees 15,000 to 25,000 robots employed in the U.S. auto industry by 1990. If the auto firms were to exactly meet their announced plans, there would be approximately 20,000 robots in U.S. auto plants by 1990.

Job Displacement

Utilizing the robot forecast by industry, and the assumption of a gross displacement rate of two jobs per robot which was strongly supported in our interviews, estimates of gross job displacement (the elimination of job tasks rather than actual layoffs of workers) can be derived. We estimate that robots in the U.S. will eliminate between 100,000 and 200,000 jobs by 1990. From 30,000 to 50,000 of these will be in the auto industry, while 70,000 to 150,000 jobs in other manufacturing industries will also be eliminated.

In addition to the assignment of robots by industry, it was necessary to forecast the applications for which they will be used. This is required if the robot population forecast is to be useful in predicting occupational displacement. Otherwise there is no way to connect the robots with the work content of specific jobs. The application areas used in our research are welding, assembly, painting, machine loading and unloading, and other.

When the robot forecast by application area and industry is matched against an occupational data base similarly organized, specific occupational displacement rates can be estimated. These results are shown in Table 3. Although the maximum overall job displacement rate in manufacturing of 1 percent through 1990 is not particularly problematical, specific industry and occupation displacement rates are very significant, even dramatic.

To begin with, the displacement rate derived for the auto industry ranged from 4 to 6 percent of all employment. But when displacement was calculated only against the production workers in the auto industry, the magnitude of displacement was from 6 to 11 percent. Even when considered to be over a period of a decade, these rates of job displacement are significant.

When specific occupational displacement rates are calculated, even more striking results emerge. Our results suggest that between 15 and 20 percent of the welders in the auto industry will be displaced by robots by 1990. Even more dramatically, between 27 and 37 percent of the production painter jobs in the auto industry will be eliminated by 1990. While displacement results are generally less significant for specific occupations in all other manufacturing, it is projected that 7 to 12 percent of the production painter jobs there will be lost in the same time frame.

The conclusion of the job displacement estimates is that while job displacement due to robots will not be a general problem before 1990, there will clearly be particular areas that will be significantly affected. Chief among these will be the painting and welding jobs for which today's robots are so well adapted. Lesser impacts will be apparent on metalworking machine operatives and assemblers. Geographically, states such as Michigan, especially the southeastern quadrant with its heavy dependence on autos, will suffer greater displacement than other states or regions.

We do not believe that this job displacement will lead to widespread job loss among the currently employed, however. Table 4 compares the average annual rates of displacement by occupation with the Bureau of Labor Statistics estimates of average annual replacement needs and total job openings for the same occupational groups. Clearly, the job displacement which can be expected is much less than the occupational replacement needs for the foreseeable future. Even in the auto industry, voluntary turnover rates historically have been sufficient to handle the reduction in force that might be required. In addition, the new General Motors-United Auto Workers contract, as one example, seems to provide adequate job security assurances, and the retraining commitment necessary to back them up. Thus we do not expect any substantial number of auto workers to be thrown out of work due to the application of robots. Any unemployment impact is likely to be felt by the unskilled labor market entrants who will find more and more factory gates closed to the new employee. Therefore, if there is an increase in unemployment as a result of the spread of robotics technology, we fear the burden will fall on the less experienced, less well educated part of our labor force.

Job Creation

Turning our attention to the job creation issue, we forecast the direct creation of about 32,000 to 64,000 jobs in the U.S. by 1990 in four broad areas: robot manufacturing, direct suppliers to robot manufacturers, robot systems engineering, and corporate robot users. The jobs in corporate robot users identify maintenance requirements for robots, while the jobs in robot systems engineering identify the applications engineering requirements for robot systems, without regard to industry of employment.

In these projections we assumed that the status quo would be maintained in both the import and export markets for robots, primarily because of a lack of any better information. But there is certainly no guarantee that U.S. producers will maintain their share of the national or worldwide market. This threat is especially menacing because of Japanese and European expertise in robotics technology.

The projections of robot-related job creation by occupation are very speculative because of the limited experience to date with robots and the uncertainties involved in predicting the future occupational profiles of firms that do not yet exist. However, the high technical component of labor demand is quite startling. It can be seen from Table 5 that well over half of the jobs created will require two or more years of college training.

The largest single occupational group of jobs created by robotics will be robotics technicians. This is a term which is just coming into general usage; it refers to an individual with the training or experience to test, program, install, troubleshoot, or maintain industrial robots. We anticipate that most of the new entrants to this occupation will be trained in community college programs of two years duration. We project that jobs for about 12,000 to 25,000 robotics technicians will be created in the U.S. by 1990. We do not anticipate a supply problem for robotics technicians, as the community college system gives every indication that they will be ready and willing to train whatever numbers are needed. In fact, our current concern is that they may, in some instances, be increasing the supply too rapidly.

Specifically, a continuation of the expansion of the last year or so in course offerings and enrollments in robotics technician programs on a national scale will very quickly swamp the ability of the industry to absorb trained people. There may already be as many students enrolled in these programs as there are annual sales of robots. For that reason, we endorse careful attention to the breadth of training. A firm grounding in theory and general principles of electronics, controls, hydraulics, etc. will stand the graduates of such programs in good stead whether they actually work primarily with robots or not.

In the auto industry, we expect the robot maintenance requirement will continue to be met by the members of the UAW Skilled Trades Council. General Motors already has agreed to a retraining effort in excess of $80 million annually. We believe the strong implication of the contractual arrangements is that auto industry employers will not be required to hire from the outside to meet their robotics technician needs. Other major robot users may follow the lead of the auto industry, but it is impossible to predict that with assurance at this early date.

There also will be a relatively large number of graduate engineers needed to implement the expansion of robotics technology in U.S. industry. We estimated the requirement from about 4,600 to 9,300 new engineers. While these numbers are comparatively small, only one-fifth of one year's production of engineers at the baccalaureate level, there is already a clear shortage of engineers, so we start from a deficit position. In addition, we face the challenge of other likely engineering demand increases as well as the historical instability of engineering enrollments. Thus it is quite likely that a shortage of engineers could compromise the expansion of robotics technology. Thus we add our voices to those calling for immediate national attention to the supply of engineers.

The most remarkable thing about the job displacement and job creation impacts of industrial robots is not the fact that more jobs are eliminated than created; this follows from the fact that robots are labor-saving technology designed to raise productivity and lower costs of production. Rather, it is the skill-twist that emerges so clearly when the jobs eliminated are compared to the jobs created. The jobs eliminated are semi-skilled or unskilled, while the jobs created require significant technical background. We submit that this is the true meaning of the so-called robotics revolution.

Policy Implications

We suspect that these research results on the impact of robotics can be generalized to other so-called "high-tech" areas. Data Resources, Inc. (DRI) has produced a forecast for Business Week of the employment potential of the 92 SIC codes labeled high technology or high-tech-intensive by the BLS. For the period 1983 to 1993, DRI projects 730,000 to 1 million jobs will be created in this sector. This is about half the decline in manufacturing employment we have suffered in the past three years due to the recession.

The most fundamental reason these high-tech employment areas will not dominate in the near future is because they are so small now. We estimate there are only 5,000 to 6,000 people employed in robotics today; only about 2,000 of these in robot manufacturing. The situation is similar for other emerging high technology industries. "High-tech hysteria" notwithstanding, we are confident that there will be more jobs created in Michigan by economic recovery than by high technology for at least the next decade.

We also believe, however, that the changes created by the introduction of the microprocessor to U.S. manufacturing in the future will alter the occupational content of the demand for labor. This will not happen overnight; it will be an evolutionary change. In fact, the skill-twist in the U.S. economy has been occurring over the past 40 years or so. We believe there will be less and less opportunity for employment by the unskilled or the semi-literate in our economy in the future. Thus while robotics and the other new manufacturing technologies do not create an immediate human resource problem, over time they will add to our existing problem; an oversupply of unskilled labor relative to demand.

When the Manpower Development and Training Act was passed by the Congress in 1962, it was designed primarily to attack the problem of technological unemployment. But as Willard Wirtz (Secretary of Labor, 1961-1969) puts it, we quickly discovered we were working on the wrong woodpile. We did not have a fundamental need for retraining of workers whose skills had been rendered obsolete by automation; we faced a growing pool of labor (especially disadvantaged youth) who had never acquired any skills in the first place.

Similarly in 1983, we believe the prophets of high-tech hysteria are fundamentally misdiagnosing the problem. We do not have an enormous displaced worker problem, if by that term one refers to workers who had good jobs with substantial seniority who have been permanently separated from their employer. The truly displaced workers, in our opinion, are those involved in plant closing situations, not simple layoff due to lagging sales. We need a coherent human resource policy to deal with the very difficult problems associated with plant closure. Hopefully the JTPA displaced worker program will evolve in that direction as local decision-makers implement actual programs.

We believe a major share of what is popularly labeled the displaced or dislocated worker problem is purely cyclical and will disappear with an adequate economic recovery. The truly structural problems will remain, however, in the face of a job market which will increasingly require significant skills for entry level employment.

Historically in the United States, we have followed a market allocation strategy for human resources. Individuals prepare themselves for the job market as they see fit. Even though substantial public subsidies may be involved, there has not been any effective planning or coordination involved. We allow students to choose their own careers with minimal constraints and only the vaguest informational support. It is not necessary to abandon this non-system, but it is necessary to make it more efficient in the task of allocating scarce resources. Human resource decisions made by individuals can be made more effective with the provision of up-to-date and reliable labor market information. In addition, many youth have not made any decision, but simply followed the path of least resistance. Increasingly this path will lead to a dead end.

We cannot perfectly anticipate future occupational needs in great detail. It would be difficult in a planned economy; it is impossible in a market economy. There are too many influences on market events to make them predictable in advance. We can, however, improve our efforts to provide intelligence about general trends and to project their direction. The problem has been that there was no adequate data base with which to discern trends as they emerged. Until very recently we were dependent on decennial census data for detail on the occupational content of our economy. Measurements ten years appart are simply not sufficient to the task, especially when the method of classification was changed with each observation as well.

I believe that the Occupational Employment Statistics (OES) survey program can provide an adequate remedy to this lack of information, if appropriately funded and developed. This would include not only the data gathering and analysis (which must be speeded up greatly if its usefulness is to be maximized) but the dissemination of the information to individual decision-makers. At a minimum, we need national projections and local data bases sufficient to make the local implications of the larger picture apparent.

The evidence on the performance of job search skills training, job clubs, and the like is sufficient to convince me that there are very significant frictional barriers to employment for some. An improved labor market information system is requisite to better performance in this area. In addition, an adequate up-to-date data base for local labor market areas would be of inestimable assistance for planning JTPA and other local training efforts. Such a data base must have sufficient occupational detail to make it useful in projecting the need for particular skills, but not so much detail that it is confusing. Again, the OES data base possesses considerable promise as a prototype for this effort.

In addition, I believe we must provide a better educational opportunity in the first instance, and move to insure that our youth take advantage of this opportunity. We must upgrade our science and technology training all along the educational continuum. We need a new national effort similar to the National Defense Education Act to upgrade preparation for the world of work. We also need the techniques and the resources to insure that all our youth acquire some useful human capital. At a minimum, we should make sure that they have sufficient skills so that they can be retrained someday, if necessary. This means basic skills like reading, writing and arithmetic. I would favor competency-based standards in these areas for high school graduation.

One hopeful element here is the development of computerized individualized instructional systems in the last few years. Such systems would seem to offer great potential for teaching a large number of skills in non-classroom environments. There should be more effort directed to developing and implementing such systems. They would of course be useful for displaced workers as well. General Motors has found the Plato system, for example, very useful in retraining older workers who do not adapt well to a traditional classroom environment.

It does not make sense that we offer special tax incentives for physical capital formation only. If one wishes to make an investment in physical capital today, there are investment tax credits, rapid depreciation through the accelerated cost recovery system, and other public subsidies available. But if one wants to invest in one's own human capital, it is only deductible if it is required as minimal preparation for the job now held. If an individual wishes to improve his/her position, s/he must bear the full private cost of such investment. This is illogical and counterproductive. Individuals and firms should receive tax credit subsidies to encourage private investment in human capital. This simple step would signal the social interest in such investment and help offset the rising cost of education due to declining direct public subsidies.

Hopeful Signs for the Future

I would like to conclude my testimony by citing some developments that have occurred or are about to occur that promise some relief from our current situation. First, and most important, I believe the signs are now unmistakable that the bottom of the recession is behind us and economic conditions will be improving. Approximately 15 percent of the laid-off auto workers have already been recalled and I believe the prospects are good for further recalls. Interest rates are down, prices are not up substantially, and tastes seem to be changing back to larger cars in the wake of stabilized oil prices.

Second, the demographic trends in the next decade appear to be favorable for reducing the additions to the labor force. While the number of youth (ages 16-24) in the labor force increased by 54 percent from 1960 to 1970 and 38 percent from 1970 to 1980, this component will actually decrease by 14 percent in the decade of the 1980s. If we can insure that a large proportion of youth entering the labor force in the '80s are prepared for the world of work, we may be able to keep from adding to the existing unemployment problem.

Third, there is widespread evidence of recognition that we have some significant human resource problems. The recent Commission report on the quality of our educational effort is but the latest example. There has been dissatisfaction with our educational performance from a number of perspectives. Perhaps this report will help bring the debate to a policy decision.

Last, there is at least a chance that the increasing incidence of labor-management cooperation in the last few years may be permanent. This is significant because of the potential productivity improvement that can accompany increased cooperation between management and labor. Japanese workers may not work any harder or any smarter than American workers, but everyone seems to agree they do work more cooperatively.

Ultimately, there is only one satisfactory solution to the high cost of labor in the U.S. since this is also the basis for the American standard of living. That solution lies in the productivity of our human resources. If we are to continue to be paid more than workers in other countries, we must produce more than they do. Careful management of our human resources is the only way I know to accomplish that.

Thank you for your attention.

Table 1

Forecast of U.S. Robot Population
by Application, 1990

	Autos		All other manufacturing		Total	
	Range of estimate		Range of estimate		Range of estimate	
Application	Low	High	Low	High	Low	High
Welding	3,200 (21.3%)	4,100 (16.4%)	5,500 (15.7%)	10,000 (13.3%)	8,700 (17.4%)	14,100 (14.1%)
Assembly	4,200 (28.0%)	8,800 (35.2%)	5,000 (14.3%)	15,000 (20.0%)	9,200 (18.4%)	23,800 (23.8%)
Painting	1,800 (12.0%)	2,500 (10.0%)	3,200 (9.1%)	5,500 (7.3%)	5,000 (10.0%)	8,000 (8.0%)
Machine loading/unloading	5,000 (33.3%)	8,000 (32.0%)	17,500 (50.0%)	34,000 (46.0%)	22,500 (45.0%)	42,000 (42.0%)
Other	800 (5.3%)	1,600 (6.4%)	3,800 (10.9%)	10,500 (14.0%)	4,600 (9.2%)	12,100 (12.1%)
Total	15,000	25,000	35,000	75,000	50,000	100,000

Table 2

Selected Estimates of 1990 Sales, Population and Growth Rates of Robots in the U.S.

Source	Unit sales 1990	Value (billions) (1980 $)	1980-90 annual growth rate (percent)	Cumulative population
Conigliaro[a]	31,350	2.0+	38	122,000
Aron[b]	21,575	1.9	36	94-95,000
UM/SME Delphi[c]	33,333	2.0+	45	150,000
Engelberger[d]	40,000	-	35	150,000
RIA[e]	-	-	35-39	75-100,000

NOTE: The 1980-90 annual growth rate and the cumulative population in 1990 are not necessarily stated directly in all of these studies but can be calculated from data that are provided.

a. Laura Conigliaro, *Robotics Newsletter,* Prudential-Bache Securities Inc., January 15, 1982, p. 7 and June 19, 1981, p. 8.

b. Paul Aron, "Robots Revisited: One Year Later," in *Exploratory Workshop on the Social Impacts of Robotics: Summary and Issues,* Office of Technology Assessment, U.S. Government Printing Office, Washington, DC, July 1981, p. 34.

c. Donald N. Smith and Richard C. Wilson, *Industrial Robots: A Delphi Forecast of Markets and Technology,* Society of Manufacturing Engineers, Dearborn, Michigan, 1982, pp. 47-51, and Donald N. Smith, Peter G. Heytler, and Murry D. Wikol, "Sociological Effects of the Introduction of Robots in U.S. Manufacturing Industry," Industrial Development Division, Institute of Science and Technology, University of Michigan, Ann Arbor, Michigan. Unpublished paper presented at the *CAMPRO '82 Conference on Computer Aided Manufacturing and Productivity,* October 1982, p. 7.

d. Joseph L. Engelberger, *Robotics in Practice,* American Management Association, AMACOM Press, New York, 1980, p. 115.

e. Robot Institute of America, *RIA Worldwide Survey and Directory on Industrial Robots,* Dearborn, Michigan, 1981, p. 30.

Table 3

Displacement Impact of Robots in the United States by Application, Cumulative 1980 to 1990

	Autos		All other manufacturing		Total	
Application	1980 employment level	Displacement range (percent)	1980 employment level	Displacement range (percent)	1980 employment level	Displacement range (percent)
Welding	41,155	15 - 20	[illegible]	[illegible]	[illegible]	[illegible]
Assembly	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Painting	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Machine loading/ unloading	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
All operatives and laborers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
All employment	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SOURCE: Employment data based upon unpublished [illegible] data provided by Office of [illegible] of Labor Statistics, U.S. Department of Labor, Washington, DC.

Table 4

Displacement Impact of Robots Compared to BLS Estimates of Job Openings

	Simple average annual displacement impact of robots 1980 - 1990			BLS average annual replacement needs 1978 - 1990	BLS total average annual openings 1978 - 1990
Application	Autos	All other manufacturing	Total	All industries	All industries
Welding	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Assembly	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Painting	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Machine loading/ unloading	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
All operatives and laborers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
All employment				[illegible]	[illegible]

SOURCE: [illegible]

a Assumes [illegible]

Table 5

Direct Job Creation in U.S.
Due to Robotics, by Occupation, 1990

Occupation	Employment: Range of estimate: Low	Employment: Range of estimate: High
Engineers	4,636	9,272
Robotics technicians	12,284	24,568
Other engineering technicians	664	1,328
All other professional and technical workers	936	1,871
Managers, officials, proprietors	1,583	3,166
Sales workers	581	1,162
Clerical workers	2,908	5,817
Skilled craft and related workers	2,163	4,326
Semi-skilled metalworking operatives	2,153	4,306
Assemblers and all other operatives	3,763	7,526
Service workers	138	276
Laborers	279	558
Total	32,088	64,176

Mr. **Bedell**. Mr. Bilirakis.

Mr. **Bilirakis**. I have no questions. I would like to thank the gentleman for a very fine presentation.

Mr. **Bedell**. Mr. Schaefer.

Mr. **Schaefer**. No questions.

Mr. **Bedell**. In your table 1, what are the percentage figures?

Mr. **Hunt**. Those represent the percentage distribution of robot population by application. So, for instance, in the low-range forecast of auto column, 21 percent of the auto robots will be doing welding tasks.

Mr. **Bedell**. Of all the robots, they will be doing that job?

Mr. **Hunt**. Right.

This was necessary in our framework, to get at specific occupational impact. So, in addition to coming up with an overall number, we tried to get at specific applications, particularly in the auto industry.

Mr. **Bedell**. On table 2, you accumulate population. What is that?

Mr. **Hunt**. Those are attempts to take directly or indirectly from these other forecasting sources what the implications of annual growth rates or target date populations would give us in 1990. We were trying to show that in terms of the forecasts that were available to us, at least a few months ago. These are comparable to our estimate of 50 to 100,000. In other words, we are a little bit on the low side.

Mr. **Bedell**. What is the first item?

Mr. **Hunt**. Conigliaro?

Mr. **Bedell**. What is 122,000? What does that say?

Mr. HUNT. The robot population; robots in use in the United States. As we read Conigliaro's forecast which does not come down in terms of how many robots are there going to be in 1990, but how many are there at intermediate dates, and what is the growth rate. So, as we interpret Conigliaro, her analysis is consistent with a robot population in the United States of 122,000 in 1990.

Mr. BEDELL. You mentioned the New York Times article that said that recovery will not bring additional workers to most plants if they would simply increase their efficiency to take care of that recovery. Do you think that is a reasonable projection?

Mr. HUNT. No, I think that is the goal. I am hopeful that the economic recovery will come somewhat faster than they anticipate. They will also find with the kind of capacity utilization that we have got, at 70 percent, that there is enormous potential for increasing output without major capital investment.

I hope we have a booming recovery; we don't expect it, but I would like to see it. I think they are going to be somewhat less than wholly successful at making that transition to a 15- to 20-percent higher sales level, with no additional work force, but that is the thrust of the goal.

Mr. BEDELL. You said that you thought small firms would be slower in adding robots——

Mr. HUNT. Yes.

Mr. BEDELL. As compared to large firms.

Mr. HUNT. Both because of the financial problem you can buy a robot that can do a lot of useful things in a $40,000 to $50,000 range. That represents about half the actual cost of making that robot work; installing it, working out the bugs, and integrating it with other equipment.

So, we are talking about a relatively high price. We are talking about even more integration problems in small firms, getting the kind of expertise that they need to help them with this.

You can't yet go—well, in a couple of places you can—but there are not many vendors, software vendors, and applications vendors available for robotics. It is largely being made up as we go along, implemented at the time. You can get a lot of help from manufacturers, but they can't do the whole job for you, so I think that is also a constraint in small business.

Mr. BEDELL. We have seen in computers a tremendous drop in the cost of computers. Do you expect a tremendous drop in the cost of robots, or do you think they stay somewhat similar in terms of real cost?

Mr. HUNT. I think that there will be some declines. Nowhere near what we have seen in computing capacity, because even the technological breakthroughs that are hoped for are not of that magnitude.

We are talking about applications breakthroughs. We are not talking about fundamental changes in the cost of robotizing, like we were in the cost of computers. But it is obvious that the reductions in the cost of computing power, the chips that make the processors, et cetera, are what make today's robots capable of doing the things they do.

As those prices come down, clearly that is reflected in the robot. As mass production ensues in robot manufacturing, costs are going to come down. These are almost being built on a one-by-one basis now. There are not many robots employed in building robots, for instance, right now They are being assembled by hand. So, clearly, there are going to be gains. I would hesitate to put a number on it.

Mr. **Bedell**. I take it you would be surprised if the cost of robots were to decline where they are half what they are today?

Mr. **Hunt**. No, I would not be surprised at that. But that would be the outer limit in terms of what I see in real terms.

Mr. **Bedell**. That would make it more possible for small firms?

Mr. **Hunt**. Absolutely.

Mr. **Bedell**. Would it not?

Mr. **Hunt**. Yes.

Mr. **Bedell**. You mentioned the BLS figures. You thought they would eliminate 1 job in 10 in the work force. That kind of went by me. Did I understand you correctly?

Mr. **Hunt**. What I was saying is that if you take the forecast of job displacement that we made, and you try to find a base of comparison; not for just simply saying that that is 1 to 2 percent of production workers, but of the job openings that are going to occur on the replacement needs basis, it represents roughly 1 in 10 of those replacement needs jobs. In other words, 1 of every 10 workers that would have had to have been hired in the absence of robots, in the next decade, will not be hired because robots will take that job.

Mr. **Bedell**. Those are from BLS figures?

Mr. **Hunt**. The one base is ours; the other base is theirs.

So, it is a rather risky business to try and make these cross-comparisons; but it is on the same occupational basis. At least it is in the right ballpark.

Mr. **Bedell**. One thing we want to look at—and we have BLS coming tomorrow—is that a lot of these projections are based to quite a great extent upon their work——

Mr. **Hunt**. Yes.

Mr. **Bedell**. Right now. You would agree?

Mr. **Hunt**. We are almost wholly dependent on the BLS to give us the basic data of who is employed where and what are they doing.

Mr. **Bedell**. Any other questions?

Thank you very much.

Oh, yes.

Mr. **Fithian**. Thank you, Mr. Chairman.

Mr. Hunt, you compared today with the sixties. Just a question. In your projections about the future, what kind of GNP growth do you crank into that?

Mr. **Hunt**. Well, we are talking about historically sustainable rates of roughly 2 to 4 percent. Now, that is consistent with a lot of other forecasts. We are not pinning this on a boom period in the eighties. We expect, unfortunately, relatively slow growth as most other forecasters do.

Mr. **Fithian**. Thank you.

Mr. **Bedell**. Thank you very much.

I appreciate your testimony very much.

Our next witness is Ted Gordon.

Mr. Gordon.

Mr. **Gordon**. Thank you, sir.

Mr. **Bedell**. We welcome you here. You represent The Futures Group, which I understand has spent a considerable time analyzing some of these concerns, and we appreciate what you have done to agricultural technology in Third World countries, and we will look forward to your assessment of the nature of change that we can expect as a result of this automation.

Mr. **Gordon**. Thank you, Mr. Chairman.

Members of the committee, I have prepared remarks which——

Mr. **Bedell**. We would hope you would summarize those; we will go through them. By the way, I should also mention that everyone's prepared statement will be entered completely in the record, and I appreciate the fact that several of the witnesses have summarized their reports.

TESTIMONY OF THEODORE GORDON, PRESIDENT, THE FUTURES GROUP

Mr. **Gordon**. Our firm is a futurist research planning, consulting organization, located in Glastonbury, Conn., and Washington, and we have performed work for the Department of State, Department of Commerce, National Science Foundation, OTA, and others, as well as private clients drawn from large corporations, and my remarks this morning are taken from those previous studies.

Mr. Hunt referred to the concern which arose when computers were first introduced, that concern proved misplaced because in retrospect computers created more jobs than they destroyed.

Common wisdom holds that new technology will always create more jobs rather than less, but it is important to raise a note of caution here. This might not be so in the case of automation and robotics because electronics has progressed so far so fast; the future for electronics is so bright and the prospects for automation in general so bright that it is important to ask whether this new revolution creates jobs or reduces them in both a relative and absolute sense.

In this testimony I am going to explore the potential for interactions between technology and the labor force and ask about directions, up or down.

As we look at the technology of electronics and automation, we see three principal trends: Improving reliability, diminishing costs, and increasing volumetric compression—that is more components in a particular volume. We have done studies which asked how long those trends we have seen in the past can continue. Those trends have been very powerful, about two orders of magnitude, a factor of 100 or so per decade.

As we look at each of those trends and try and imagine where they might go, some barriers become apparent but almost without exception, those barriers can be bridged: We have reached the conclusion that these three trends can continue for another two decades at about the current rate. For example, one barrier is reached by photolithography, the technology principally used in printing silicon chips. This limit is determined by the closeness of two lines which have to be drawn on the chips. That limitation is established by a wave length of light. You can only get the lines so close together. Once that boundary is reached, however, there are other technologies available which use shorter wavelength energy to obtain even further compression. That seems to be the picture for decades into the future. One boundary can be leaped over by another technology.

This leads us to expect by the year 2000 or so, electronic technology—automation—will improve over current capabilities by a factor of 10,000 or so. We can make a kind of index out of it.

This gain assumes that the markets are there to draw the technology out. The costs will drop, as I said initially and performance improve. These forecasts are well founded. To imagine that automation and robotics will be the same in the year 2000 as they are now would be a misplaced belief.

In addition to these general trends in electronics and automation, for robotics in particular, there are three other trends worth noting: The first is in improvement in sensors; the second is improvements in artificial intelligence, a field which is progressing fairly well; the third is the miniaturization of mechanical components in general, using the same technology as printed circuits but applying that same technology to mechanical parts. For example, some recent work resulted in the complete printing on a very small chip of an entire mass spectrometer, not just the electonic elements but the mechanical parts as well, all packed into a very small volume.

Artificial intelligence, the development that I referred to a moment ago, requires the ability to sense and operate on sensed information, to draw "judgments" from these observations, and perform adaptively.

Machines with artificial intelligence will not "reason" in the sense of human reasoning, but will like most of us, observe data, learn, and arrive at pragmatic rules of behavior that are good enough to accomplish the ends that the machines have been programed to achieve. With artificial intelligence a robot of the sort that we are talking about here can perform functions which we will recognize as being more cognitive as time progresses.

Focusing for a moment specifically on robots and the development of robot technology, we see the accuracy of manipulation improving from about .02 inches today to a thousandth of an inch in the year 2000. Repeatability of placement, being able to move from one position to another, improving by a factor of 5. Meantime, between failure—that is, maintenance of the robots themselves—improving by a factor of 5 from 1,000 hours or so in the near future to 5,000 hours. Fault detection in robots moving from mostly human detection to self-detection, self-check. Speed will improve by a factor of 4 or so. Also, to some extent at least, robots will move toward self-teaching, sensing from silhouette to 3-D, and memory capacity will expand greatly.

Expanded memory is the key to artificial intelligence. Finally, information processing is moving from conventional to parallel architecture, which means simultaneous analysis of problem sets that the robot is dealing with. So that leaves us with the question about the future of the number of robots in the United States. This is not certain, by any means, as other testimony has indicated this morning.

Our estimates are really quite consistent with others that have been mentioned, 100,000 robots or so by the year 1990, and then growing considerably, at a slower rate, but on a bigger base to about half a million by the year 2000.

It is not adequate to simply describe those robots in terms of units; we must ask about the capability of those units. Future robots will have different capabilities in the future; we have also made an estimate of the number of people-equivalent of a robot, going from about two today—which coincides fairly well with the first testimony we have this morning to, and this is stretching it—to about 5 by the year 2000.

Now, given those assumptions, and some others which I will mention, we computed the levels of unemployment which might result. We used the Department of Labor's estimate of labor force size between now and the year 2000. Presuming the GNP was assumed to grow at 2.7 percent per year—which was in the middle of the band that Dr. Hunt talked about—we presumed that productivity would grow at a rate of 1.5 percent per year, which seems a reasonable expectation in view of this technology. These are scenario assumptions mind you, and might prove to be wrong. But with these assumptions, unemployment did not grow and remained roughly constant.

If the economy grows at about 2.7 percent per year, it will absorb the productivity increases, the increasing number of workers expected to enter the labor force, and a half million robots of increased capability by the year 2000.

It is very important then to follow national policies that encourage economic growth. With lower economic growth, unemployment will grow. This is the key to the unemployment picture.

When we focus on particular industries, the situation is much different, again, as Dr. Hunt suggested. We examined the production of passenger automobiles. That narrow segment of the labor force employed about 270,000 workers over about the last 7 years.

On the average, the number of passenger automobiles produced during that time ranged from 6 to 9 million units. We assumed—again, these are scenario assumptions—that output in this industry would grow at the rate of 3 percent a year, so that by the year 2000, about 10 million automobiles per year would be produced. Productivity growth in this industry may actually be higher than average because of CAD/CAM and PERT and improvement in other manufacturing procedures, but we assumed it would grow at 1.5 percent per year, as for the economy as a whole. Finally, we projected that the number of robots in this industry would grow to 5,000 by 1985 and 25,000 by this year 2000.

In this instance, displacement of workers in the industry would be very heavy, approaching 50 percent or so by 2000. These results come directly from the assumptions; other people can make other assumptions and come up with different numbers but at least this estimate tends to size the extent of the issue. The central point is: While robots displace 1.9 percent of the labor force as a whole, the impact can be much greater in specific industries, and in this case, can indeed so.

The policy implications are clear. We should develop our full output potential because it is only through economic growth that full employment can be realized. In the presence of such policies, automation which improves productivity—and robotics—work to the advantage of the country in improving quality, lowering the cost of our products, fostering domestic economic growth and the quality of life that comes with it, and importantly improving the competitiveness of our products on the world market.

My prepared statement includes a report of a study that we did recently which extends the scope of the issue to developing countries. It is a piece of work that we presented at the Woodlands Conference earlier this year called "Global Consequences of Improving Productivity." Basically, we examined Third World country labor force trends, and asked how changing productivity in Third World countries would impinge on employment in those countries.

Now, the situation is really quite different than for our country. Population growth rates in developing countries are very high, and because there are a large number of people of pre-labor-force age, their big bulge in labor force size is yet to come. The question is, will there be jobs for all those kids that are going to come of age?

If developing countries followed patterns of recent years in industrialization, the first sector to be industrialized will be agriculture, which is the heaviest employer of the people in the labor force.

We found that the people freed from the agricultural sector will not all be able to find jobs in the industrial and services sectors, although employment in both sectors will grow as productivity and the economic condition of those countries improves. On the one hand, improvements in agriculture are required for the indigenous production of food and that requires capital to make agriculture more capital intense, which frees labor, but the alternative jobs for that portion of the labor force, particularly in countries that have high population growth rates, will be hard to find.

Labor needs in developing countries will rise in sectors other than agricultural, but these needs will not compensate for the labor oversupply. That led us to the conclusion that development policies of poorer countries would have to consider jobs and employment as well as economic growth as policy targets.

Thank you, and I would like your questions, please.

Mr. **BEDELL**. Thank you very much, Mr. Gordon.

Mr. Bilirakis.

Mr. **BILIRAKIS**. Just very quickly, sir, your percentage figures on productivity and GNP: Do they take into consideration the potential rate increase in the use of robotics?

Mr. **GORDON**. Yes, sir.

Mr. **BILIRAKIS**. They do?

Mr. **GORDON**. Indeed.

I treated them somewhat separately. I assumed productivity growth of 1.5 percent per year, and in addition to that, a half million robots by the year 2000.

Given that productivity, given that number of robots, and a GNP growth rate of 2.7 percent, we can absorb the additional people that BLS says will join the labor force, and keep unemployment constant. It is a very simple calculation, but the numbers balance.

Mr. BILIRAKIS. But isn't the bottom line of robotics, or the concept of robotics, to increase productivity?

Mr. GORDON. Absolutely.

Mr. BILIRAKIS. To increase GNP?

Mr. GORDON. Absolutely, and to improve the quality of the products.

Mr. BILIRAKIS. And a competitive quality, which, of course, ties right into increasing productivity—more people buy, and that sort of thing.

Mr. GORDON. Yes, sir.

Mr. BILIRAKIS. That is the bottom line of it all.

Mr. GORDON. Indeed so.

Let me mention how sensitive the calculation is to growth of the economy. I said 2.7 percent makes it balance. If I were to say 2.3 percent, the situation would be very, very different. At 2.3 percent, unemployment grows tremendously; at 3.1 percent, on the other hand, unemployment falls off, and we are looking for workers.

Those sensitive to that assumption——

Mr. BEDELL. Are those tables included with your statement?

Mr. GORDON. Only one of them, but I will make the other two available.

Mr. BEDELL. Which one is included?

Mr. GORDON. The basic one, which show productivity at 1.5 percent and the one that assumes 2.7 percent GNP growth.

Mr. BEDELL. I think it would be most beneficial if we could have the other, too, because we really don't know what is going to happen.

Mr. GORDON. I would be glad to furnish them.

Mr. BILIRAKIS. I have nothing further, Mr. Chairman.

Mr. BEDELL. Mr. Schaefer?

Mr. SCHAEFER. Thank you.

Just a couple of questions. How many firms are now involved in the making of robots to sell?

Mr. GORDON. I don't know the answer to that. Didn't we have that question earlier this morning?

Mr. BILIRAKIS. I believe 30.

Mr. BEDELL. I think 30 to 35.

Mr. SCHAEFER. I would imagine then, of course, when we look at 500,000 by the turn of the century, it would be something like the computer business, in a competitive sense.

Mr. BEDELL. Would the gentleman yield? The information that I wrote down was that he said there were 140 in Japan and that there were 30 or 35 here in the United States.

Mr. SCHAEFER. One other question: In your studies in this particular area has anything come up about the safety factor again? I asked this question earlier as far as some of the hazards.

Mr. GORDON. I would quite agree with Mr. Weisel's testimony that there are several principal drives for replacing human labor with robotic labor. One of the most important is safety. Robots are extremely useful in dangerous situations, in tedious situations, in boring situations, that offend human work.

So these are really important drives for the conversion to robotics. They are safer; they produce higher quality, and they get rid of jobs that people don't like to do.

Mr. **Schaefer**. No further questions.

Mr. **Bilirakis**. Would the gentleman yield a moment?

Sir, in your opinion, and I will call it a gamble and I am not sure that is appropriate, but is the gamble worth it to America and to the American people?

Mr. **Gordon**. The gamble?

Mr. **Bilirakis**. When we consider the very high potential of the lost jobs versus the gains and the benefits.

Mr. **Gordon**. It is hardly a gamble, sir.

Mr. **Bilirakis**. I said the word is not quite appropriate.

Mr. **Gordon**. The reason I pose my response that way is, were we not to do it, we would lose our competitive edge and the growth rate that I am insisting is required here would be lost. All chance of it would be lost; so it seems to me that we would have to take that gamble and do it well, and in parallel, foster policies that would promote an economic development.

Mr. **Bilirakis**. Thank you, Mr. Gordon.

Mr. **Bedell**. I certainly appreciate your testimony very, very much.

You indicated, if I understood you correctly, that for automobile workers, you projected the decline of something like 50 percent in that number of workers?

Mr. **Gordon**. Yes, sir, but this is a very extreme projection.

Mr. **Bedell**. That is quite different. Mr. Hunt projected 10 percent.

Mr. **Gordon**. He was talking 1990; and I was talking the year 2000.

Mr. **Bedell**. Oh, you are not in great disagreement, on that?

You indicated, if I understood you correctly, that you thought unemployment would remain about the same, if we have 2.7 percent growth in GNP, and 1.5 percent in productivity?

Mr. **Gordon**. Yes, sir.

Mr. **Bedell**. That is over 10 percent right now. Do you mean that it will stay at 10 percent roughly?

Mr. **Gordon**. As I ran through these numbers, I was looking at something that roughly balanced. If I were to increase that to 2.8 percent growth, then unemployment would drop. It is very, very sensitive to that number.

Mr. **Bedell**. What were your figures?

Mr. **Gordon**. As I took off from a base of a GNP of $3 trillion in 1982; and at the rate of growth that I used——

Mr. **Bedell**. Where did you get that figure?

Mr. **Gordon**. Oh, I have it here.

That is in published statistics for the country.

Mr. **Bedell**. The concern I have is while I have been in the Congress, I have never yet seen projections that were not overly optimistic what the economy was going to do. Maybe that was just because the period that I have happened to serve I think there is a tendency for people in Government to want to hope that things are going to be better. Do you have the figures on our GNP increase for the last 3 years, for example?

Mr. GORDON. I think so.

Mr. BEDELL. I don't want to take a lot of time; my understanding is that they would be substantially less than the 2.7.

Mr. GORDON. Oh, I am certain of that. I am certain of that, and what I am dealing with here is a forecast for the next 18 years, and we all know how bad economic forecasting has been.

But let me just say that the 2.7 is right in the middle range of economists that are brave enough to forecast over that time domain.

It is not the highs; not the lowest. I think it is attainable.

Mr. BEDELL. You said if it were to be 2.3 percent, it made a big difference in your projections?

Mr. GORDON. Oh, yes, that is correct.

Mr. BEDELL. What would you forecast unemployment to be if it were 2.3 percent? Do you know?

Mr. GORDON. By the year 2000, 16 percent.

Mr. BEDELL. Is that right?

Mr. GORDON. The gross national product, according to the numbers that I have, in current dollars for 1981, was $2.94 trillion and in 1982, it was $3.06 trillion. This is from the Survey of Current Business.

Mr. BEDELL. Do you have 1980?

Mr. GORDON. I don't have 1980 with me. Maybe somebody else has.

Mr. BEDELL. I would say, almost constant.

Mr. HUNT. If you will, in constant dollars. I just have the chart in front of me. In 1972 dollars, the GNP has been constant since 1979.

Mr. BEDELL. Since 1979, about constant?

Mr. HUNT. Yes.

Mr. GORDON. And in constant dollars diminished somewhat between 1981 and 1982.

Mr. BEDELL. OK. Well, so that's 1, 2, 3 years, it has been roughly constant?

Mr. GORDON. Yes.

Mr. BEDELL. What would GNP have to increase in order to get unemployment down to 5 percent?

Do you have that figure?

Mr. GORDON. I would have to guess at that from the numbers that I have, but something on the order of 3 percent.

Mr. BEDELL. OK

I presume if it stayed constant—that is where it is today, with no increase—it would be a disaster.

Mr. GORDON. We would be in terrible trouble, not because of robotics, but the cost, the labor force size is growing, and yes, everything.

Mr. BEDELL. Yes, everything. There was the time when instead of working 40 hours, we were working 60 hours. That has constantly declined. If we were to see a decline in hours of work, would that tend to solve the problem if we don't see our GNP increase?

Mr. GORDON. Sure, they are tradeable exactly. All the figures that I gave you presumed a constant workweek.

Mr. BEDELL. Sure.

Mr. **Gordon**. If we were to decrease the number of hours of work by 10 percent, then the number of workers required would increase by 10 percent.

Mr. **Bedell**. Sure.

Mr. **Gordon**. It is a tradeoff.

Mr. **Bedell**. If you did end up with 2.3 percent growth in GNP, and 16 percent unemployment—I am not saying how you go about doing it—but if you were to lower the work week by 16 percent, you would——

Mr. **Gordon**. One hopes that is increased leisure rather than a forced reduction in the workweek.

Mr. **Bedell**. Sure, sure.

But we have seen that move over the total period.

It appears to me that what we have seen is an increase in productivity worldwide. With the problems that you mentioned in the developing world, wherein their economies are going to have a pretty difficult time, any big increase in markets from those developing countries would be questionable under most projections, and increased competitiveness in world markets, which we have already seen in agricultural products I think you would expect to see in these other products.

Do you see that adversely affecting the growth of GNP?

Mr. **Gordon**. In our country?

Mr. **Bedell**. Yes.

Mr. **Gordon**. I think the nature of the product that we sell to developing countries is going to change over time. It is really quite possible to imagine a world in which trade with developing countries—albeit with other products involved—is still a very important part of our economy and theirs as well, and I really picture that. For example, in the case of agriculture, as we move through this time period, I see our export product changing to a degree from the export of food which we have grown to sell overseas, to agricultural inputs, chemical inputs, implements, to help them to develop their own production. In other words, we export to them what they require for the development of their economy. It is probably likely to cross a number of industrial sectors.

Mr. **Bedell**. Many of those countries have a substantial foreign debt at this time, and our debt service is taking an awfully large part in the exchange they gain from the sale of their products overseas.

Mr. **Gordon**. Yes, sir.

Mr. **Bedell**. Do you see that as seriously and adversely affecting their ability to import those products that we might wish to sell them, or do you think that they are going to somehow solve that problem so they will have the exchange so they can buy the things we might like to sell to them?

Mr. **Gordon**. I have failed to discover anywhere a solution to the problem of developing country debt. I haven't read a good idea on how that can be solved, and because of the problems in the development of the economies of poor countries, that I alluded to here, I think most poor countries who have borrowed a lot of money will have a very tough time repaying their debt. That is not to say that we won't find ways to accommodate or to continue exports to those countries.

Part of the debt will be paid; some of it will be in trade; money comes in; money goes out. They raise their foreign exchange by different mechanisms, and perhaps even borrow additional money. I think trade goes on, but by the same token, I think it is very difficult to imagine how debts will be completely paid in the short term.

Mr. **Bedell**. So, you do not see that as seriously impinging upon our ability to export to those countries.

Mr. **Gordon**. I think we will, and I mean we in a very plural sense here—all exporting countries—will find a way to accommodate trade.

Mr. **Bedell**. Mr. Fithian.

Mr. **Fithian**. I just have one question.

Dr. Hunt was using the 2- to 4-percent figure for GNP growth; now, what would unemployment be under your projection using your productivity increased figure at 2 percent? And what would it be at 4 percent?

Mr. **Gordon**. I don't know the answer, but I can tell you it would be awful at 2 percent; and very good at 4 percent.

I mean, we would need workers at 4 percent.

Mr. **Bedell**. Could you get us those figures?

Mr. **Gordon**. I would have to run it——

Mr. **Bedell**. That is what I mean——

Mr. **Gordon**. Oh, sure.

Mr. **Bedell**. We would appreciate it if you would send those in.

Mr. **Gordon**. May I put one caution in, please?

The calculation that I used, to derive at those numbers is a very simple approximation. It makes a lot of assumptions about participation rates of the labor force, about what productivity really means, about how many workers that robots would replace. The numbers I am quoting are really just the results of those assumptions. So please treat them with that idea in mind. The figures represent order of magnitude estimates designed to size the problem.

Mr. **Bedell**. I think your testimony has been helpful. I appreciate it very, very much.

[Mr. Gordon's prepared statement with attachments follows:]

PREPARED STATEMENT OF THEODORE GORDON, PRESIDENT, THE FUTURES GROUP

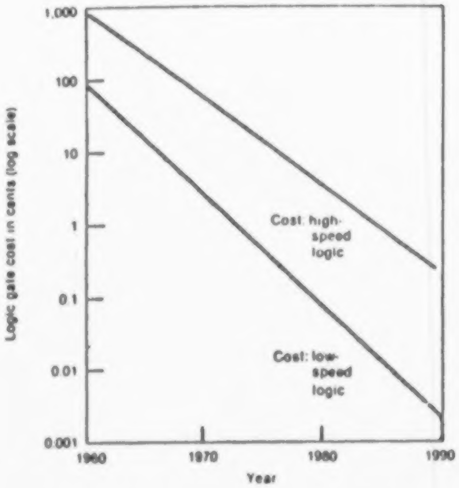
Mr. Chairman and Members of the Committee: My name is Theodore Gordon. I am President of The Futures Group, a firm specializing in long-range planning for both private and government clients. Our principal offices are located in Glastonbury, Connecticut, and Washington, D.C. Our government clients include the Department of State, Department of Commerce, National Science Foundation and other government agencies, and our private clients are generally large corporations from the electronics, communication, information, manufacturing, pharmaceutical, chemical and financial industries. In general, our studies are pragmatic and directed toward policy issues that can be influenced by future changes. We have performed a number of studies recently that relate to advancing automation and robotics, and I have drawn my remarks this morning from this prior work.

When computers were first introduced, there was a great deal of concern that unemployment would result wherever computers were used. In fact, this was not the case; wherever computers were used, more jobs were created. Common wisdom holds that this situation will always continue, but this might not be so. Electronic devices are so advanced and the prospects for automation so bright, that the net effect of introducing such new technologies may be to improve total output with less labor required in both a relative and absolute sense. I will explore the potential for such technology-induced unemployment in this testimony.

This technology is profound. There are three principal hardware trends that characterize electronic hardware today: reduction in cost, improvements in reliability, and increases in packing density—that is, the number of components that can be packed into a given volume (Figure 1). All of these trends have been running at the rate of about a factor of 100 or so per decade since 1960; our studies indicate that these trends have another two decades or more to run. As limits are reached during this period, new technologies offer potential for further breakthroughs. For example, photolithography (the technology required for printing microcircuits on silicon) is limited at present by the distance between lines that can be drawn optically. This, in turn, is fixed by the wavelength of light. Once this limit is reached, conventional photolithography impedes further progress toward miniaturization. However, just behind this conventional technology lies the possibility for using shorter wavelength energy in these processes, for example, ultraviolet or X-ray imaging.

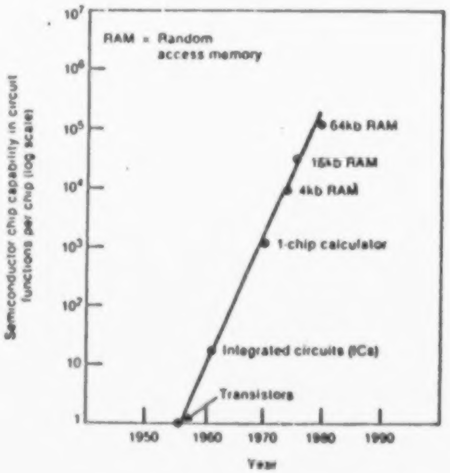
If we assume that electronics has another two decades or so to run at current rates of improvement, the electronics of the year 2000 will be improved by a factor of 10,000 or so. And with that kind of improvement possible, specific applications that are possible challenge the imagination. Some of the more important applications that loom on the immediate horizon are summarized in Figure 2.

PROJECTIONS OF LOGIC COST PER GATE



SOURCE: OFFICE OF TECHNOLOGY ASSESSMENT AND PRIVACY PROTECTION STUDY COMMISSION.

INCREASE IN CAPABILITY OF SEMICONDUCTOR CHIPS FROM 1956 TO 1980



SOURCE: INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS, IEEE SPECTRUM, VOL. 17, JUNE 1980, P. 48. U.S. MANUFACTURES OF SEMICONDUCTOR CHIPS INCLUDE FIRMS SUCH AS INTEL, MOTOROLA, TEXAS INSTRUMENTS, ROCKWELL, NATIONAL SEMICONDUCTOR, AND ZILOG.

Figure 1

IMPORTANT ELECTRONICS APPLICATIONS OF THE NEXT DECADE

- ROBOTS
- COMPUTER-AIDED DESIGN
- GRAPHICS/FINE ARTS
- EDUCATION
- INFORMATION AND DATA BASE (FACSIMILE, TELETEXT, VIDEOTEX)
- MEDICAL USES
- MICROCOMPUTERS
- ELECTRONIC PHOTOGRAPHY, "BOOKS"

Figure 2

In addition to these continuous trends, it is worth noting two other developments of significance; these are discontinuities and can significantly affect the application of electronics in the future. First, the same techniques that are being used to produce very large scale integrated circuits are also being applied to the manufacture of small mechanical devices. For example, a mass spectrometer, a device for determining the constituent elements of gases and other fluids, has been "printed" on a chip. This is more than simply printing the electronics on a chip, as is commonplace in very large scale integrated circuitry; rather, the whole machine—valves and all—is part of the printed apparatus.[1] The second new development is the coming of age (within the next decade) of artificial intelligence, the simulation of human intelligence by computers. Artificial intelligence requires ability to sense, operate on sensed information, draw "judgments" from these observations, and perform adaptively in view of these judgments and changing circumstances. Machines with artificial intelligence will not "reason" but will, like most of us, observe data, learn, and arrive at pragmatic rules of behavior that are good enough to accomplish their ends. Progress in this field has been impressive under people such as Ed Feigenbaum at Stanford and Marvin Minsky at MIT, but we expect the field will accelerate even faster in the future as the price for computer memory continues to drop and parallel processing of information is developed further. By processing information in parallel through several alternative paths, computational speed is improved, redundancy is achieved, and computer operation becomes much closer to what some people feel describes the functioning of the human brain.

With artificial intelligence, a robot can perform cognitive functions. Recent studies at The Futures Group have resulted in projections of robot technology that illustrate the enormous potential for this field. Robotic accuracy is defined as the absolute error of the equipment in six dimensions when trying to reach a computed destination (Figure 3). Repeatability is a measure of the ability to return to a manually taught prior position. Electric robots have an accuracy of 0.020 inches today, moving toward 0.001 inches by the year 2000, while hydraulic robots have an accuracy of 0.200 inches today, moving toward an accuracy of 0.010 inches by the year 2000. Repeatability for electric robots is 0.005 today, moving toward 0.001; hydraulic machinery has repeatability of 0.050, moving toward 0.010 by the year 2000.

MTBF will increase from 1,000 hours in 1980 to 5,000 hours in 2000.

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[1] "Silicon Micromechanical Devices," *Scientific American* (April 1983).

FORECASTS OF ROBOT TECHNOLOGY

	STATE OF THE ART		
FEATURE	1983	2000	
ACCURACY OF MANIPULATION	.02" .2 "	.001" .020"	(ELECTRIC) (HYDRAULIC)
REPEATABILITY OF PLACEMENT	.005" .050"	.001" .010"	(ELECTRIC) (HYDRAULIC)
MEAN TIME BETWEEN FAILURES	1000 HRS	5000 HRS	
FAULT DETECTION & REPAIR	MOSTLY HUMAN	MOSTLY SELF-CHECK	
SPEED FOR STANDARD PATTERN	4 SEC	1 SEC	
PROGRAMMING	EXTERNAL	EXTERNAL & SELF-TAUGHT (A.I.)	
SENSING - VISUAL	SILHOUETTE	3-D	
MEMORY CAPACITY & TYPE	MAGNETIC MEDIA	VASTLY EXPANDED MAGNETIC AND OPTICAL MEDIA	
INFORMATION PROCESSING		PARALLEL ARCHITECTURE	

Figure 3

Robotic mean-time-to-repair will be 10–15 minutes for electric robots versus 30–60 minutes for hydraulic robots. Electric robots have increased their speed from 6 seconds in 1977 (for a standard pattern) to 4 seconds today; and that speed should decrease to under 1 second for the same pattern in the year 2000.

Robots can be designed to interact with other equipment via external interfaces and to react with human beings via spoken language.

Within the next decade or so we can expect to see very simple means for programming robots and, with the advent of artifical intelligence, robots that learn through experience. For example, a robot could be adaptively programmed to change its positioning or sequence in order to minimize rejection rates.

A distinguishing feature of robots is their versatility—their ability to be used in a multiplicity of applications. In the future, robots will become more general-purpose, in the sense that their implements can be utilized in a variety of jobs without much cost penalty. Vision and sensing will improve; 3-D perceptions will be commonplace.

In 1970 there were only about 200 robots in the United States; by 1982 the number had increased by more than a factor of 20, to a total of about 4,500. As is well known, the Japanese have made much more extensive use of robots in production—estimates place the number at about 14,000 by the end of 1981.[2] (If mechanical transfer devices are included, the 1982 total for Japan jumps to 67,000, and that for the United States to 45,000. On this same basis, France has 39,000 and the Soviet Union 3,000.[3]

The number of robots likely to be in use in the future is not certain by any means, but large increases seem certain. The number of robots in manufacturing quadrupled between 1979 and 1981. Senator Lloyd Bensten, at a Joint Economic Committee session, suggested that by 1990 between 100,000 and 150,000 robots could be place in the United States, with Ford and General Motors using 30,000 robots between them.[4] Forces encouraging this growth include:

Improvements in the technology itself, which increase the number of applications that can be made of these machines.

Diminishing costs for given robotic capability as a result of "learning-curve" improvements.

Increasing costs of human labor.

Growing sophistication on the part of management, facilitating the switch to robotics.

On the negative side, factors that limit the speed of diffusion of technology include:

The size of the required investment.

Institutional inertia that slows the adoption of automated technologies.[5]

The rate of capacity utilization.

Now the question is, Will such progress in robotics and automation in general create jobs or eliminate them? The answer is, of course, it will do both; at constant levels of output, it will eliminate jobs because the robots will perform jobs that human workers currently perform, and automation, properly applied, will improve productivity, that is, increase output per man-hour. Some people argue that as automation progresses and more people will be required to produce the machines, and that as people are freed from their currently dull, repetitive, drudgerous, and sometimes dangerous activities, unemployment will not diminish but the quality of the work and its scope will increase. While this has generally been the case in the past, note that robotics and the new wave of automation have some new attributes. First of all, robots can and probably will manufacture robots and other automated equipment. Furthermore, as Robert Ayres, professor of engineering and public policy at Carnegie-Mellon University, points out:

> While robotics is a kind of automation, and automation in itself is not new, robots are the first kind of automation that directly replaces workers by doing what many workers do—namely to manipulate parts, load, unload, and operate other kinds of machines and/or portable tools. Almost the sole justification for purchasing industrial robots is to eliminate workers.[6]

Automobile manufacturers already find it possible to operate robots for $6 an hour compared to $20 per hour for skilled labor.[7]

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[2] Ayres and Miller, "Industrial Robots on the Line," *Technology Review* (May/June 1982).

[3] *Iron Age* (March 19, 1982).

[4] *Electronic News* (April 18, 1983).

[5] Sar Levitan and Clifford Johnson, "The Future of Work: Does It Belong to Us or to the Robots," *Monthly Labor Review* (September 1982).

[6] *Electronic News* (April 18, 1983).

[7] *Monthly Labor Review* (September 1982).

Just how many jobs will be displaced by continuing automation and robotics? The situation is summarized in Figure 4. We have created a scenario which involves several critical assumptions. The U.S. Department of Labor expects the labor force to grow from its present level of 110 million to 134 million by the year 2000. We presume that productivity grows at about 1½ percent per year as a result of automation; that GNP grows 2.7 percent per year and that the number of robots grows from a currently installed base of 5,000 to 500,000 by the turn of the century. (As mentioned earlier, Senator Bentsen suggested about 100,000 robots by the year 1990, so this forecast represents an ambitious growth in the last decade of the century.) Suppose, further, that the effectiveness of each robot also grows. Today a robot is equivalent to about two persons; we have assumed that by the turn of the century a robot could replace five workers. With these assumptions, the percentage unemployed remains essentially constant—that is at today's level. The contribution of robotization to this picture is relatively minor: in the year 2000, 500,000 robots, displacing five workers each, represents only 1.9 percent of the labor force expected at that time.

While the picture presented in Figure 4 is a homogeneous snapshot of the labor force as a whole, certain industries will be more affected by robotics than others. In general, these are industries in which mechanization of production yields lower cost, higher quality, diminished production time, improved efficiency, or improved worker safety. In these industries, the impact of robotics can be considerable. For example, the production of passenger automobiles has involved a labor force that averaged about 270,000 over the last seven years. On the average, this labor force produced about 30 automobiles per employee, while production during this interval from 6.2 to 9.2 million units. Now assume the following: the employees available for passenger automobile production grow at the same rate as the labor force as a whole. The employees required, however, are affected by level of production of automobiles, improvements in productivity, and introduction of robots. It we assume that production grows at 3 percent a year, so that by the year 2000 more than 10 million units are manufactured in the United States, and that productivity grows at 1.5 percent per year (as previously assumed), and that the number of robots grows from 5,000 in 1985 to 25,000 in the year 2000, then less than half of those who might ordinarily have been assumed to be available for employment in this industry will be required. This effect is reduced as production of the industry increases.

The policy implications, it seems to me, are clear. We should follow policies that permit us to develop our full output potential. In the presence of such policies, automation and robotics work very much to our advantage in improving quality, lowering costs of our products, and thus foster domestic economic growth and improve competitiveness of U.S. products on the world market.

As a matter of interest, I have also attached a recent paper prepared by our company for the Fourth Woodlands Conference on Sustainable Growth, titled "Global Consequences of Improving Productivity," describing an analysis of the consequences of advancing technology on the labor force of developing countries. In this instance, the techniques include not only automation that can be used to some extent by many countries, but other technologies that have the effect of increasing productivity in all sectors. We set out to compare available manpower with required manpower, that is, to find the prospects for employment in developing countries, given the realities of population growth and expectations about changes in productivity and growth.[8] We found that the net effect of increasing productivity in the developing world is likely to be an increase in incomes for those working but a decrease in the percentage of the labor force that is employed. This increase in productivity per worker is the only way in which per capita incomes will eventually rise; however, it appears that, at least in the short term, increasing unemployment will be the cost of that development.

Diffusion of technology from developed countries to developing countries has been and is well under way. In agriculture, industrialization is proceeding in almost every country. For example, smaller percentages of the labor force are engaging in agriculture, almost everywhere.

In Brazil the percentage changed from 45 percent in 1970 to 36 percent currently.

In the Ivory Coast the percentage changed from over 90 percent to 85 percent.

In Indonesia the percentage changed from 75 percent to 64 percent over the last 10 years.

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[8] "The Revival of Enterprise," paper presented by Theodore J. Gordon at The Third Biennial Woodlands Conference on Growth Policy, October 28–31, 1979.

Our calculations were based on cross-country correlations for 124 countries in the period 1979–1980. The correlations related changes in labor force and productivity to the state of development, as measured by GDP per capita.

We found that conventional development patterns would make more people available from the agricultural sector than the industrial and services sectors could absorb in the short term, resulting in net unemployment and most likely urban overcrowding by unemployed people (Figure 5).

Figure 6 shows labor force growth rates expected over the next two decades in many developing countries. The highest growth rates will occur in the countries of Africa and the Middle East, where growth of 3–4 percent a year is expected in many countries. These countries will be hard pressed to provide employment for the large number of young people entering the labor force each year. The situation should be less severe in many of the countries of Latin America, where labor force growth rates will be lower.

Our LDC analysis suggested the following:

The current trends in productivity-related technology will lead to increasing unemployment in the agricultural sector. Although labor needs will be rising in other sectors, these needs will not compensate for the labor oversupply.

Economic growth targets and the policies by which those growth targets are pursued may have to consider employment effects more explicitly.

It may be necessary to make efforts to increase employment generation even if it slows the pace of development in order to reduce the extent of absolute poverty caused by underemployment.

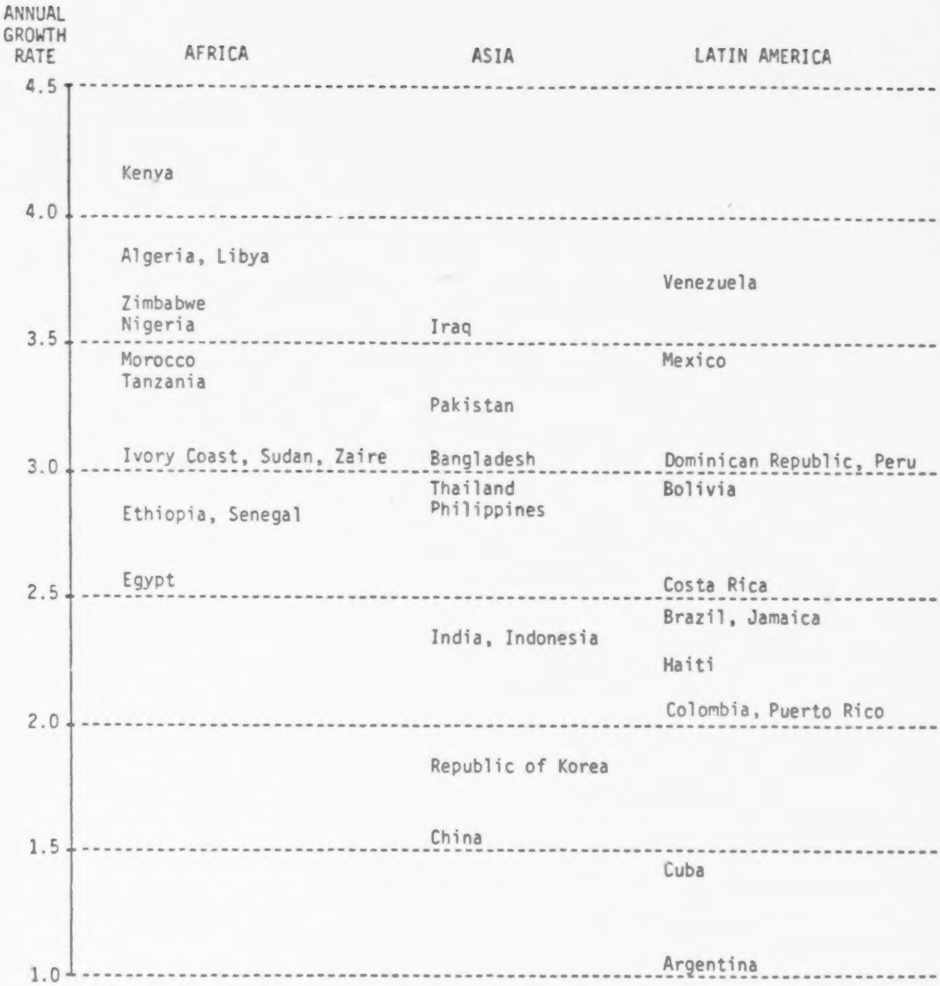
New agricultural policies designed to maximize agricultural employment may be useful in many countries, not only from the standpoint of food production, but also as a solution to the looming problem of unemployment.

Without continued control of population growth rates, the situation will get worse.

FIGURE 5.—SUMMARY OF MODEL RUNS FOR ALL DEVELOPING COUNTRIES

Run	Assumption		1980	2000	Difference from base run (percent)
Base run	GDP growth equals 5.2 percent/yr. Population growth equals 1.9 percent/yr.	GDP/CAP	$600	$1,120	
		Unemployment (millions)	350	570	
High growth	GDP growth equals 6.5 percent/yr.	GDP/CAP	600	1,462	+30
		Unemployment (millions)	350	577	+1.2
Low Growth	GDP growth equals 4.3 percent/yr.	GDP/CAP	600	942	−16
		Unemployment (millions)	350	559	−1.9
High production growth	Productivity by 2000 is 20 percent higher than base case.	GDP/CAP	600	1,135	+1
		Unemployment (millions)	350	800	+40

LABOR FORCE GROWTH 1980-2000



SOURCE: GLOBESCAN II (The Futures Group, Glastonbury, Connecticut, 1982).

Figure 6

TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE 24, 107–124 (1983)

Global Consequences of Improving Productivity*

THEODORE J. GORDON and JOHN STOVER

Introduction

World population today stands at about 4.6 billion and is growing at the rate of about 1.7% per year. About 1.8 billion, or 39%, of these people are in the labor force. Precise figures on unemployment do not exist but the International Labor Organization has estimated that as many as 450 million people, or 25%, are unemployed. Obviously, this is a vast oversimplification—employment exists at different levels of intensity. Many people who are out of work and who would like to work have simply become discouraged and have given up seeking employment; many people are employed in "off the books" activities and are simply not counted in any kind of official surveys. Nevertheless, this datum is the best at hand: unemployment, 25%.

Unemployment, underemployment, and poverty are unholy handmaidens. Without work, the poor remain poor. Without work, there are no savings to stimulate capital investment. Without work, political structures—even political ideologies—cannot survive.

Through the early 1960s, the common wisdom held that poverty and unemployment in developing countries could be overcome by increasing productivity and improving economic growth in developing countries. Policies of the United Nations were generally directed toward this end. The implicit assumption was that if economic growth could be achieved, employment would increase and poverty would mitigate.

By the mid-1960s, however, questions were being asked about whether the fruits of development would "trickle down," about whether the route to development was important in alleviating poverty. Today, the policy emphasis seems to have shifted from economic growth to a more direct focus on employment-based strategies and, for better or worse, to strategies that stress redistribution of wealth from rich to poor.

The situation is enormously complex. Any fair and comprehensive examination of the problem of reducing poverty would have to be concerned with not only the productivity of labor, but the productivity of capital, the prospects for accumulating capital, the economic overhead caused by unfortunate and burdensome dependency ratios, sectoral

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*This article was presented at the Woodlands Conference on Sustainable Societies: Future Roles for the Private Sector, which was held November 7–10, 1982 at The Woodlands, Texas.

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differences that exist in the balance between productivity, employment, and income, and many other concomitant social, economic, and political factors that affect the status and prospects for the individual.

In this paper we have addressed only a small—but very important—part of the problem: the relationship between economic development, productivity, population, and employment. Stated simply, we set out to compare available manpower with required manpower, that is, to find the prospects for employment in developing countries, given the realities of population growth and expectations about changes in productivity and economic growth. We shall present a more detailed explanation of our approach shortly but, to set the stage:

> Working with a unique data base, we forecasted GDP sectoral distribution and labor force productivity that could be expected in the process of development.
>
> Then, using detailed demographic projections, we computed both the expected number of people who would be in the labor force in developing countries over time and the employment required to achieve a given level of national achievement.
>
> We reasoned that if the available labor supply exceeded the employment required to achieve a particular level of growth, unemployment, underemployment, or, at very least, increased leisure would occur. If, on the other hand, the size of the labor force required was larger than the expected number of people in the labor force, incentives would exist for increasing productivity or participation rates.

As a result of this work, we shall be presenting a number of forecasts which, for most countries, indicate the likelihood of excess labor. Our plan in presenting this material is to begin with a brief discussion about the technological revolution that makes these questions timely and relevant. Then we shall describe our sources of data and modeling approach. Finally, we shall present our conclusions about future prospects for productivity and employment.

The Technologies

We are entering an era in which enormous improvements in productivity can be made in most sectors by the application of capital. In many instances, for a given level of improvement, capital requirements will diminish (for example, through the application of complex electronic instrumentation and robotics). Although improvements in productivity will almost certainly accelerate economic growth, these improvements can be at the expense of jobs. Initially, when computers were introduced there was a great deal of concern that unemployment would result wherever computers were used. In fact, this was not the case; wherever computers were used, more jobs were created. The common wisdom holds that this situation will always continue, but this might not be so. Electronic devices are so advanced and the prospects for automation so bright, that the net effect of introducing such new technologies may be to improve total output with less labor required in both a relative and absolute sense.

Increasing productivity of the sort provided by these technologies leads to increasing income per worker, a major goal of development. If, however, increasing productivity also leads to less employment, the result could be higher incomes for those working and poverty for those who are unemployed.

Technologies that affect jobs are of two general sorts: *evolutionary*, that is, technologies that exist in developed countries and reach developing countries through normal mechanisms of geographic diffusion such as trade, offshore operations of multinational corporations and foreign education; and *revolutionary*, that is, technologies that bring profound, step-function increases in productivity in both developed and developing countries. While many revolutionary technologies are currently apparent, they are not yet present in any economy. In the first category is a great array of agricultural and manufacturing machines and management techniques that include tractors, combines, large-scale earth-moving equipment, PERT scheduling, and numerically controlled machinery. In the second category are technologies such as robotics, genetics, and automation of design and manufacturing processes.

Diffusion of evolutionary technology from developed countries to developing countries has been and is well under way. In agriculture, industrialization is proceeding in almost every country. For example, smaller percentages of the labor force are engaging in agriculture, almost everywhere.

In Brazil the percentage changed from 45% in 1970 to 36% currently.
In the Ivory Coast the percentage changed from over 90 to 85% during the same period.
In Indonesia the percentage changed from 75 to 64% over the last 10 years.

Industrialization can also be measured in terms of mechanization:

In 1970 Chad had 93 tractors; today it has over 150.
Pakistan had 200 harvesters in 1970, and today has over 450.
Peru went from 10,000 tractors in 1970 to over 13,000 currently.

Although labor costs are important in determining the pace of introduction of evolutionary technology, policies unrelated to labor supply can also be important: exchange rates, subsidized credit and import duties have promoted the spread of mechanization in such countries as Pakistan, Egypt, and Brazil.

It is the revolutionary technologies that promise profound change and will lead both developed and developing countries into uncharted economic areas.[1] Genetic techniques, for example, can greatly affect agricultural productivity. Through genetic techniques, plants may be modified to become more disease resistant, require less irrigation, become tolerant to irrigation with brackish water or saltwater, reduce photorespiration, and improve photosynthetic efficiency. Genetic techniques also might lead to the creation of new plant strains that are essentially self-fertilizing.

Genetic techniques can improve productivity in other ways as well. Using genetic techniques laboratory scientists can take scrapings of the fungus that causes southern corn leaf blight, extract individual cells, strip the cell walls to obtain the protoplast, and in a remarkably short time select out cells that are resistant to the toxin. Ordinary breeding methods would take several plant generations, but such tissue culture permits location of the "one-in-a-million" resistant cell within a week.

Cloning of individual plant cells should certainly be feasible. This would permit developing new varieties through laboratory production of seedlings. To date, the technique has been most successfully applied to floral crops, and it is now possible to have an entire greenhouse full of identical flowers. Work will soon be going on to adapt the technique to rice, carrots, and tobacco.

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[1] The technological forecasts mentioned here are drawn from a study conducted by The Futures Group that involved interviewing agricultural scientists around the world. Staff members of The Futures Group talked directly with 240 or so experts in agronomy, agricultural engineering, animal science, aquaculture, climatology, entomology, plant breeding, molecular biology, water use, and other technologies. The people interviewed included those in scientific communities in the United states, the People's Republic of China, the Philippines, Japan, Israel, France, and West Germany. These people were actively engaged in basic and applied research in academic institutions, government and quasigovernment facilities, and private business firms.

In our recent study of agricultural technology, we reached the conclusion that genetic technologies of the sort just described have a potential for increasing productivity by 10–20%.

Other nongenetic techniques also promise to improve productivity or increase the acreage in productive use. These include the following:

Advanced irrigation and water use technology. Drip irrigation is close to the ultimate potential in high efficiency water use, but cost limits application to high-value crops. Alternatives for other crops include low energy precision application (LEPA) and surge-flow irrigation. Laser-leveling is a proven method of reducing irrigation water requirements.

Hybridization of plants not currently hybrid and development of new crops. Breakthroughs are being reported in developing hybrids for wheat, cotton, beans, and improved rice hybrids. A perennial corn plant is a possibility. This should result in substantial increases in wheat, cotton, beans, and rice yields.

Improved protein content of forage crops. Immediate gains are most likely to be derived from improved management of forage crops—determining optimum time to cut, field drying methods, handling methods. A major goal is rearing beef and dairy cattle entirely on pasture, which may become feasible given development of high-protein grasses. This would have the effect of freeing grain now used in feedlot beef production.

Improved saltwater tolerance in plants. Two different approaches are promising: changing irrigation techniques and plant-breeding for salt tolerance. Drip irrigation allows growing some crops with seawater for irrigation. A California researcher has grown barley using undiluted seawater on sandy soil. Tissue culture and somatic hybridization should speed development of salt-tolerant varieties. This would eliminate the need to "desalinize" land plagued by salt buildups, and result in opening of marginal lands to production, particularly in arid and coastal areas and slowdown in depletion of freshwater reserves.

Marine farming and aquaculture. This is an infant industry, wide open for exploitation. Many LDCs are ahead of the developed nations in fish-farming technologies. While disease control will become an important problem with larger, confined fish populations, there is considerable potential for integrating fish farming with agriculture in LDCs. Fish are becoming an increasingly important source of protein in human diets and the trend is likely to continue. Fish production does not compete for resources used in production of other forms of food.

New cultural practices. There is a major trend toward multiple cropping and minimum tillage in order to increase output per acre and reduce inputs required for production. Further development of short-season varieties will speed the trend toward multiple cropping. Minimum tillage is a compatible development because it decreases the between-crops time interval required for land preparation. This would increase annual output per unit of land area and reduce costs per unit of output.

New designs for pesticides. Integrated Pest Management (IPM) is on-line and being adopted internationally. New developments are likely to center on more narrow spectrum pesticides to minimize adverse environmental impacts. Most current interest is in a "biorational" approach. This would provide a gradual reduction in pesticide use per unit of land in crops.

These and other technological developments suggest that the number of people required in agricultural production can drop, while agricultural production grows at a rate that keeps pace or exceeds population growth rate, even considering the lag in technological diffusion from developed to developing countries. However, it is not obvious that these technologies *will* be employed because the realities of politics, economics, and infrastructure control the rate at which agricultural practices change.

This litany of technologies-on-the-threshold raises Promethean images. Growing world population demands increased agricultural output and this probably outweighs all other considerations. But to the degree that such technologies promise output with lower labor content per calorie, employment growth may not keep pace with output growth.

The situation in manufacturing and services is simiar. Here the key technological discontinuity is automation—the integrated circuit and its myriad applications: communications, entertainment, education, design production, office machinery, timekeeping, organization and retrieval of data, conversion of data to information and information to policy. These and the agricultural technologies suggest a vast potential for increased economic activity. To call the next two decades the time of the new agro–industrial revolution may lack literary pizzazz, but may be quite literally accurate. An attribute of many of these technologies is their ability to increase output with lower labor input, and this feature concerns us here: Will economic activity grow fast enough to generate the required employment in its wake, given the realities of population growth of the next two decades?

The Modeling Approach

To restate our objective in a slightly different way, we sought to find out whether growth in productivity, population, and economic development was balanced—or if imbalanced, whether they leaned toward increasing or decreasing employment prospects.

We were fortunate in having two excellent data sources available. The first set of data was derived from our project on Resources for Awareness of Population Impact on Development (RAPID), a continuing activity performed by The Futures Group under contract to the Agency for International Development. This five-year project is designed to improve the level of awareness and knowledge of high-level officials in developing countries concerning the effects of population factors on development. In this work, an analysis is conducted for each selected country, which determines the likely effect of different rates of population growth on the achievement of the country's development goals. Among the components of development that have been examined in detail for various countries are: labor force and employment, GNP and GNP per capita, agriculture, education, health, housing, urbanization, water, forests, and environment. These analyses form the basis of presentations to senior government officials in each country; the presentations include the use of color computer graphics and interactive computer models. The use of the computer permits us to make interactive changes during the presentation in response to questions from participants. A data base of information for over 60 developing countries has been prepared in this work and in-depth analysis is being conducted for more than 40 countries.

The second source of data was a data base constructed by The Futures Group known as GLOBESCAN. This data base contains historical, current, and forecasted demographic and economic variables for 140 countries. These data include: total population, population by sex, population by age, population by urban/rural residence, number of households, labor force, gross national product, income per capita, and income distribution. In addition, more than 100 other items are provided; these detailed data include economic structure and growth, trade, investment, debt, foreign reserves, exchange rates, and mineral and energy resources.

This GLOBESCAN data base is also a forecasting system. It is unique in the sense that it exists on a computer disk, for either the Apple II or TRS-80 microcomputer. The model allows the user to update the data, to change inputs and assumptions, and reestimate the forecasts that are contained as a baseline on the disk. For example, with this computer program a user may enter information describing a particular segment of the population and project the number of people in this segment. In order to investigate conditions in a particular country, a user might request that the program provide estimates of the number of all males between the ages of, say, 15 and 45, or all people with per capita incomes above $500. The model would then automatically produce such forecasts.

The GLOBESCAN system contains information from data files of other organizations such as the World Bank, the United Nations Population Division, and the International Monetary Fund. It also includes information not available in such sources gathered from the countries of interest themselves. Major advantages of GLOBESCAN are that it accumulates these data in a single place and treats data on a consistent basis; furthermore, since it is available within a single computer source, the data can be manipulated rather easily for statistical programs.

Description of the Analysis

In order to examine the relationship between productivity growth and labor force growth, we calculated several correlations using cross-country data for 124 countries for the period 1979–1980. Our goal was to relate changes in labor force and productivity to the state of development, as measured by GDP per capita. First, we determined the

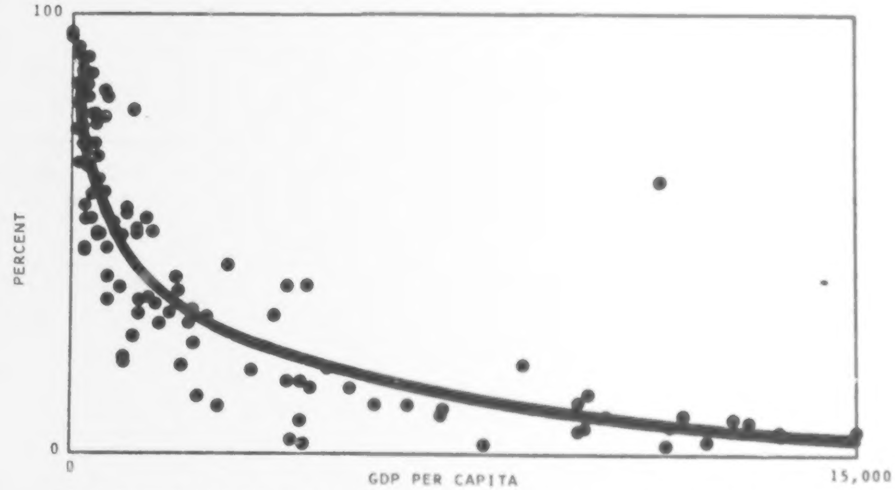

Fig. 1. Percent of labor force in agriculture vs. GDP per capita: $Y = 217.4 - 30.51 \times \ln(\mathrm{GDP/CAP}) + 0.86 \times \ln(\mathrm{GDP/CAP})^2$; $R^2 = 0.79$.

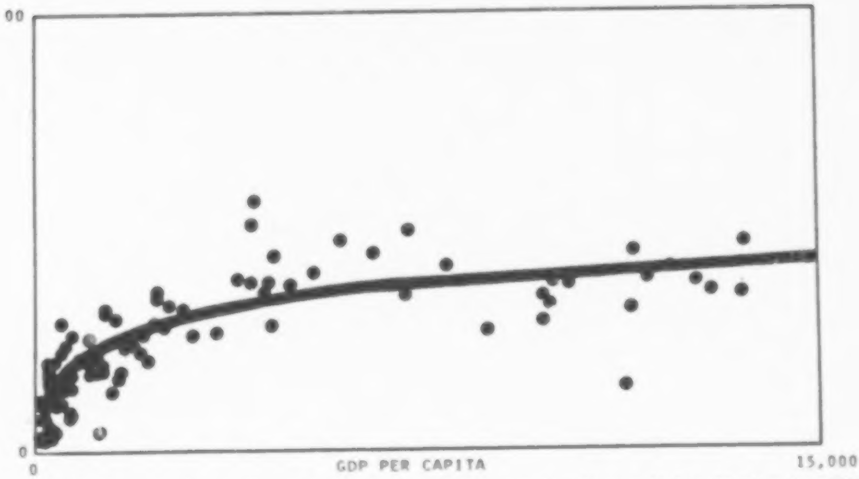

Fig. 2. Percent of labor force in industry vs. GDP per capita: $Y = -46.4 + 11.48 \times \ln(\mathrm{GDP/CAP}) - 0.24 \times \ln(\mathrm{GDP/CAP})^2$; $R^2 = 0.71$.

relationship between GDP per capita and the sectoral composition of the labor force. Figures 1, 2, and 3 show the percent of the labor force in agriculture, industry, and services as a function of GDP per capita. Figure 4 summarizes these results, showing how the labor force changes from almost entirely agricultural-based activities at the early stages of development to less than 25% of the labor force once GDP per capita increases to about $4000. The steepest decline appears to take place up to about $500 per capita.

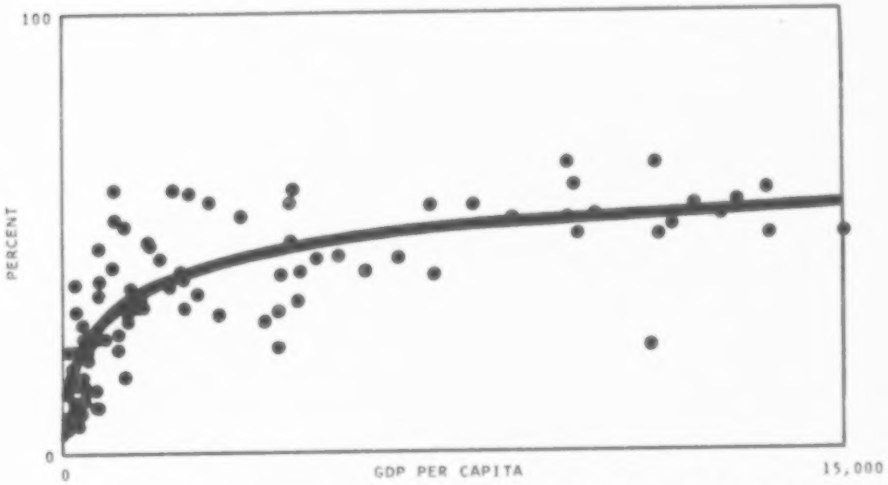

Fig. 3. Percent of labor force in services vs. GDP per capita: $Y = -71.7 + 19.19 \times \ln(\mathrm{GDP/CAP}) - 0.62 \times \ln(\mathrm{GDP/CAP})^2$; $R^2 = 0.68$.

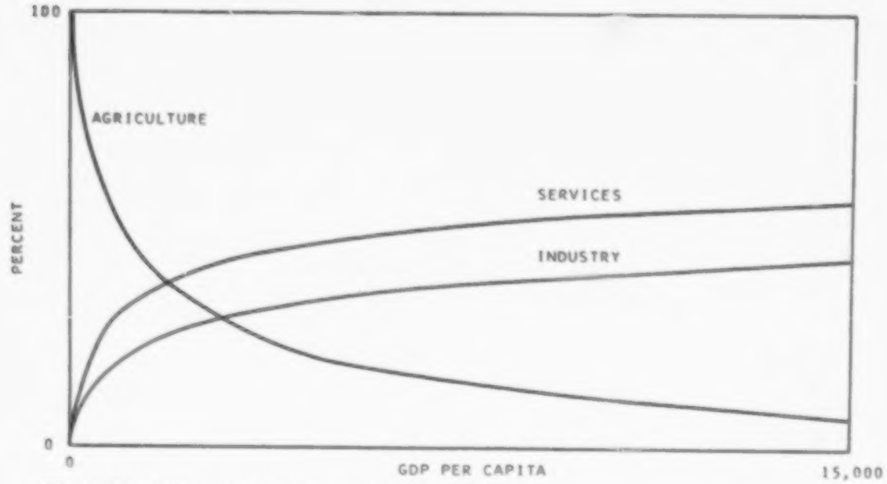

Fig. 4. Distribution of labor force vs. GDP per capita.

The changing composition of GDP by sector is shown in Figures 5, 6, and 7, and summarized in Figure 8. A similar pattern can be seen here. As a country develops, its industrial and service sectors form a larger and larger share of the total output.

The third piece of this puzzle is the change in labor productivity with development. Figures 9, 10, 11, and 12 show the relationship between GPD per capita and productivity

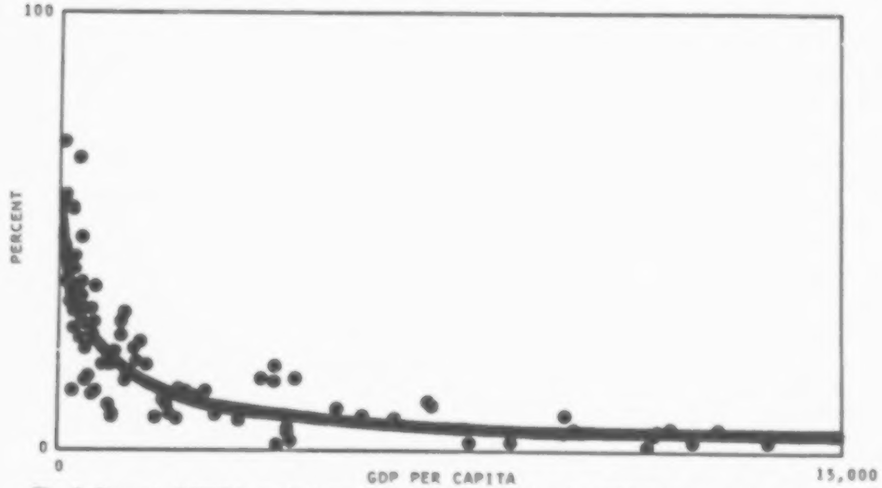

Fig. 5. Percent of GDP in agriculture: $Y = 193.1 - 38.26 \times \ln(\mathrm{GDP/CAP}) + 1.93 \times \ln(\mathrm{GDP/CAP})^2$; $R^2 = 0.77$.

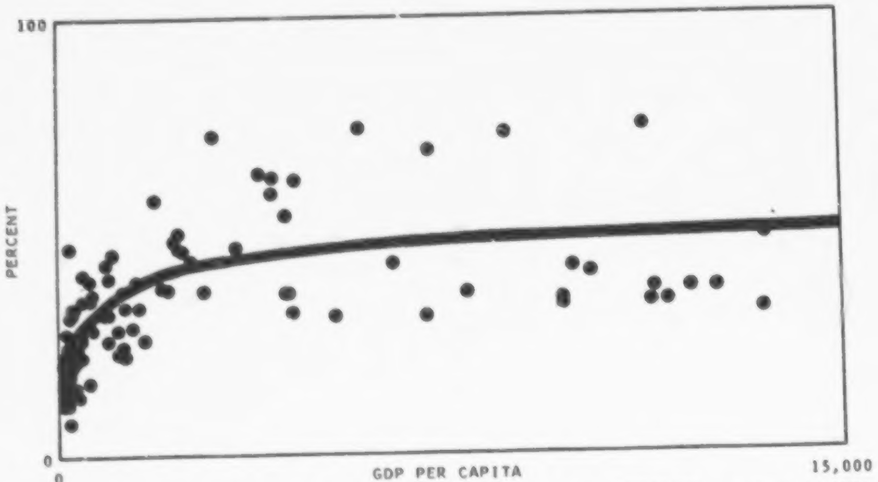

Fig. 6. Percent of GDP in industry: $Y = -79.2 + 24.28 \times \ln(\text{GDP/CAP}) - 1.13 \times \ln(\text{GDP/CAP})^2$; $R^2 = 0.49$.

in agriculture, industry and service. (Since data on employment are unavailable for most developing countries, the productivity shown in these charts is output per labor force participant.)

Using these relationships, we can investigate the changes that take place with development and their effect on employment. For any given level of GDP per capita we

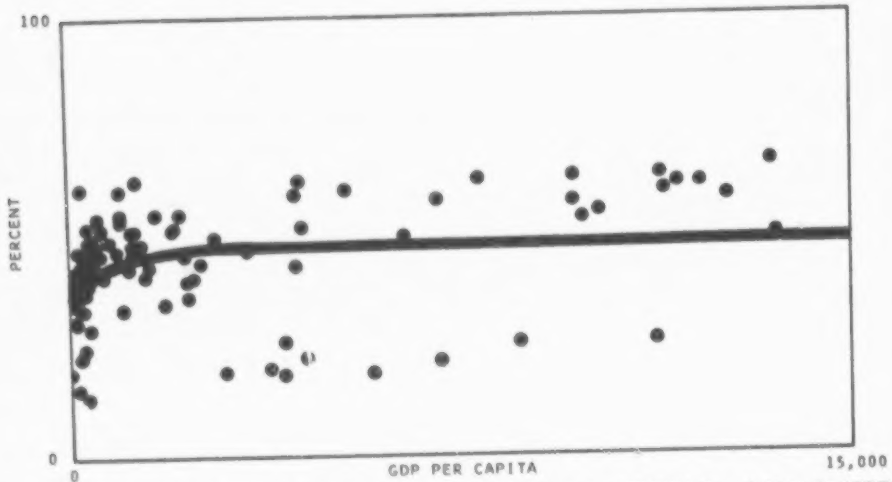

Fig. 7. Percent of GDP in services: $Y = -18.9 + 15.32 \times \ln(\text{GDP/CAP}) - 0.89 \times \ln(\text{GDP/CAP})^2$; $R^2 = 0.08$.

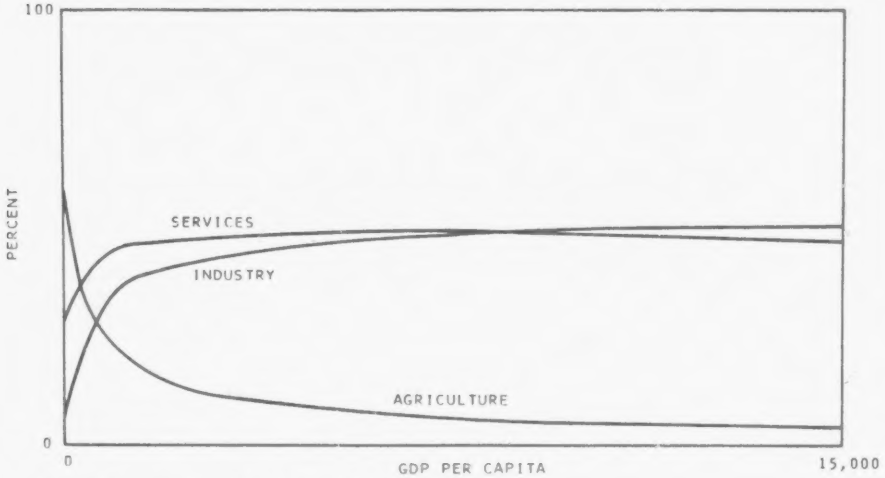

Fig. 8. Distribution of GDP vs. GDP per capita.

can calculate labor force productivity, the distribution of labor force by sector, and the distribution of GDP by sector. Then, for any given labor force size we can calculate GDP in each sector and, using the productivity equation, the employment by sector. Comparing this employment with labor force by sector results in the unemployment/underemployment estimates shown in Figure 13.

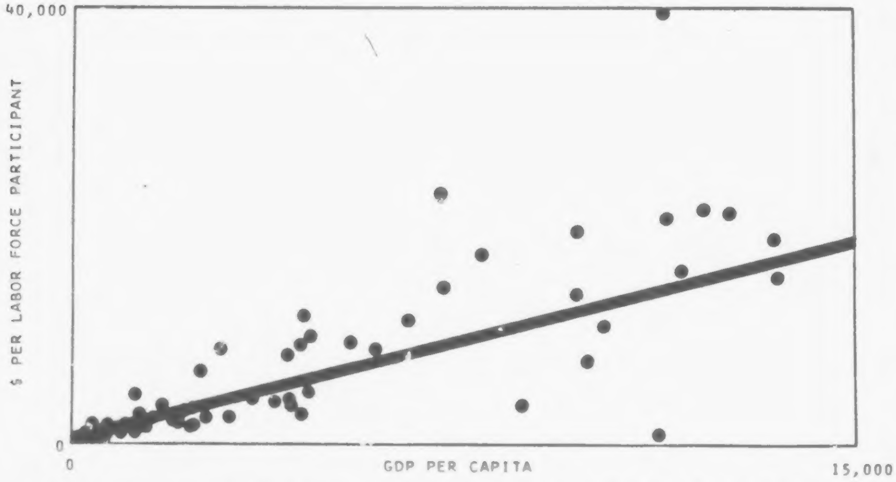

Fig. 9. Agricultural productivity vs. GDP per capita: ln (Prod) = 0.3628 + 0.9824 × ln (GDP/CAP); R^2 = 0.89.

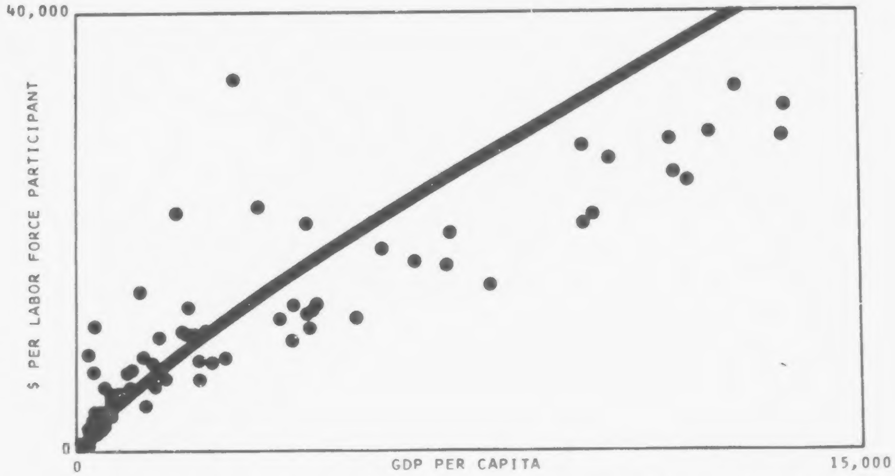

Fig. 10. Industrial productivity vs. GDP per capita: ln (Prod) = 2.6787 + 0.8374 × ln (GDP/CAP); R^2 = 0.82.

To be more precise, the regression equations shown in Figures 1–12 can be used to directly calculate the unemployment rate for a given level of GDP/capita. Using agriculture as the example we have:

percent GDP in AG = *f*(GDP/capita) (1)
percent LF in AG = *f*(GDP/capita) (2)
AG PROD = *f*(GDP/capita)/ IN AG UNEMP (3)

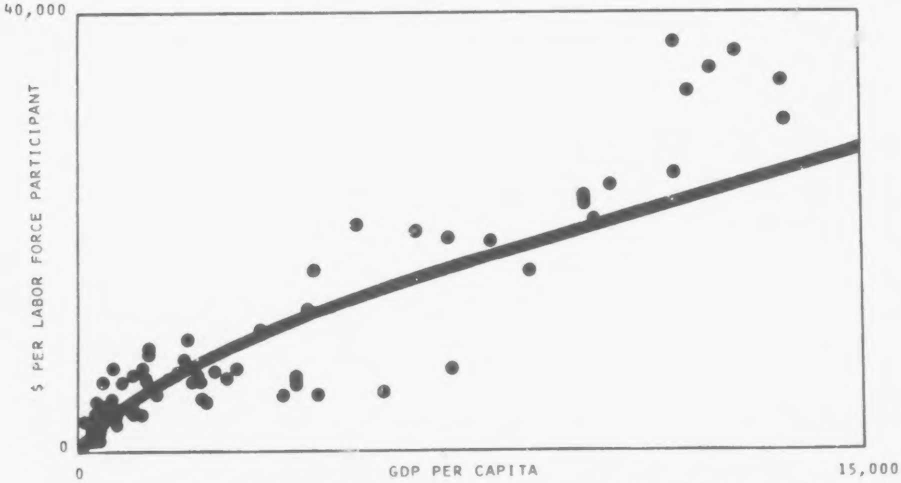

Fig. 11. Service productivity vs. GDP per capita: ln (Prod) = 3.7833 + 0.6671 × ln (GDP/CAP); R^2 = 0.82.

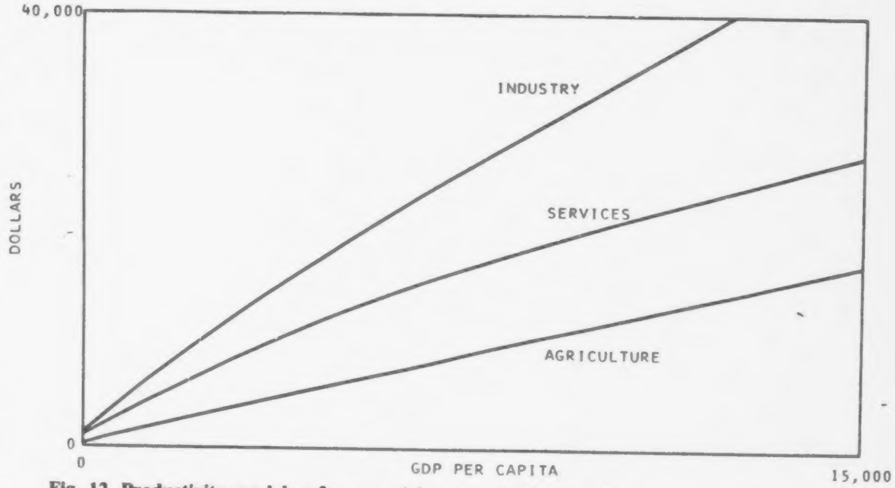

Fig. 12. Productivity per labor force participant vs. GDP per capita.

where

GDP/capita = gross domestic product per capita,
percent GDP in AG = percent of GDP in agriculture,
percent LF in AG = percent of LF in agriculture,
AG PROD = productivity in agriculture (output per worker),
IN AG UNEMP = initial unemployment rate in agriculture. (Since the regression equation was developed using output per labor force participant, some of whom are unemployed, it must be divided by the unemployment rate to yield output per worker.)

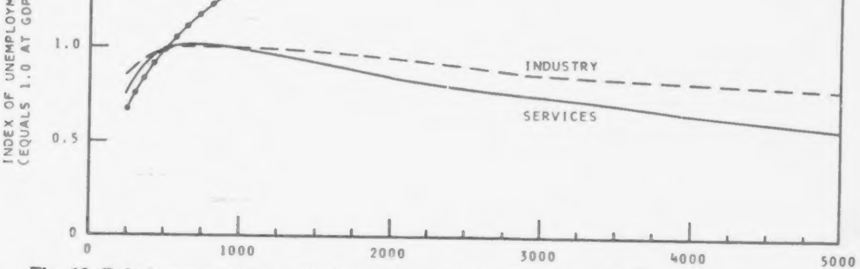

Fig. 13. Relative unemployment/underemployment by sector vs. GDP per capita.

Using these relationships we can calculate employment as output divided by productivity:

$$\text{EMP AG} = \text{GDP} \times (\%\ \text{GDP in AG})/\text{AG PROD}, \tag{4}$$

where

EMP AG = employment in agriculture,
GDP = total gross domestic product.

The total labor force is assumed to be the population multipled by the participation rate. The labor force in agriculture is the total labor force multiplied by the percentage in agriculture.

$$\text{AG LF} = (\%\ \text{LF in AG}) \times \text{POP} \times \text{PART}, \tag{5}$$

where

AG LF = labor force in agriculture,
POP = total population,
PART = participation rate (assumed constant).

The unemployment rate is one minus the ratio of employment to labor force.

$$\text{AG UNEMP} = 1 - \text{EMP AG}/\text{AG LF}, \tag{6}$$

where

AG UNEMP = the unemployment rate in agriculture

By substituting in equation (6) from equations (4) and (5) we have

$$\text{AG UNEMP} = 1 - \text{GDP/capita} \times \frac{(\%\ \text{GDP in AG})/\text{AG PROD}}{(\%\ \text{LF in AG}) \times \text{PART}}.$$

By specifying a level of GDP per capita, the entire right-hand side of the equation can be determined from equations (1)–(3). Thus, for each level of GDP/capita there is a corresponding level of unemployment.

In each sector we wanted to see whether the decline in the percentage of labor force in agriculture is sufficient to offset the increases in labor productivity. Figure 13 shows the change in unemployment and underemployment from the current levels, which are indicated by an unemployment/underemployment index of 1.0 at the 1980 average GDP per capita of almost $600.

In agriculture, productivity growth appears to occur faster than the shift of labor out of the sector leading to a steadily increasing rate of unemployment and underemployment. This is an interesting result because we know that migration from rural to urban areas—one of the major causes of the decline in the fraction of the labor force in agriculture—takes place only partly due to rising productivity. Certainly, many people leave the rural area because of a lack of steady employment or low wages. However, many young people who might have found work in agriculture migrate because of the attractions of urban life, better living conditions, and more exciting things to do. It appears that even with this migration, increasing productivity wins the race and too many people are likely to be available in the agricultural sector.

The role in this transition of government policies that discriminate against agriculture is very complex and is not explicitly included in our simple model. For example, many governments have policies designed to keep urban food prices low. These policies often have the effect of depressing prices for farm products. This often discourages the farmer from making maximum efforts to raise yields or utilize the land to the fullest. While this may slow the pace of mechanization it may also act to keep agriculture employment low by underutilization of the land.

In the industrial and service sectors, we see a somewhat different picture. Up to GDP per capita of about $500 unemployment and underemployment increase; beyond that point they begin to decline. Since the most rapid decline of the labor force in agriculture takes place up to $500, it appears that the large influx of agricultural workers causes the industrial and service sector labor force to grow faster than employment opportunities. Arthur Lewis described this process: industry benefits during the early stage of development because it is able to draw upon a surplus pool of cheap labor from rural areas.[2] Apparently the attraction of these jobs with their higher wages initially draws even more workers than the sector can accommodate, although not enough to reduce underemployment in agriculture.

In order to examine the effect of these trends over the next 20 years we have constructed the simple model shown in Figure 14. This model uses the relationships discussed earlier and adds a new function relating the savings rate to GDP per capita. This relationship is shown in Figure 15. We have used this model to project the situation for all developing countries. Although such a gross aggregation hides the very different situations that are experienced by individual countries, it is useful to give some indication of general trends.

The steps in using this model are as follows:

1. Begin with 1980 values of GDP, population, and labor force participation rate for all LDCs.
2. Assume a GDP growth rate, a population growth rate.

For each year in the future:

3. Calculate the population

$$\mathrm{POP}_t = \mathrm{POP}_{t-1} \times (1 + \text{population growth rate}).$$

4. Calculate GDP

$$\mathrm{GDP}_t = \mathrm{GDP}_{t-1} \times (1 + \text{GDP growth rate}).$$

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[2] W.A. Lewis, Economic Development with Unlimited Supplies of Labor, *Manchester School* XXII (1954).

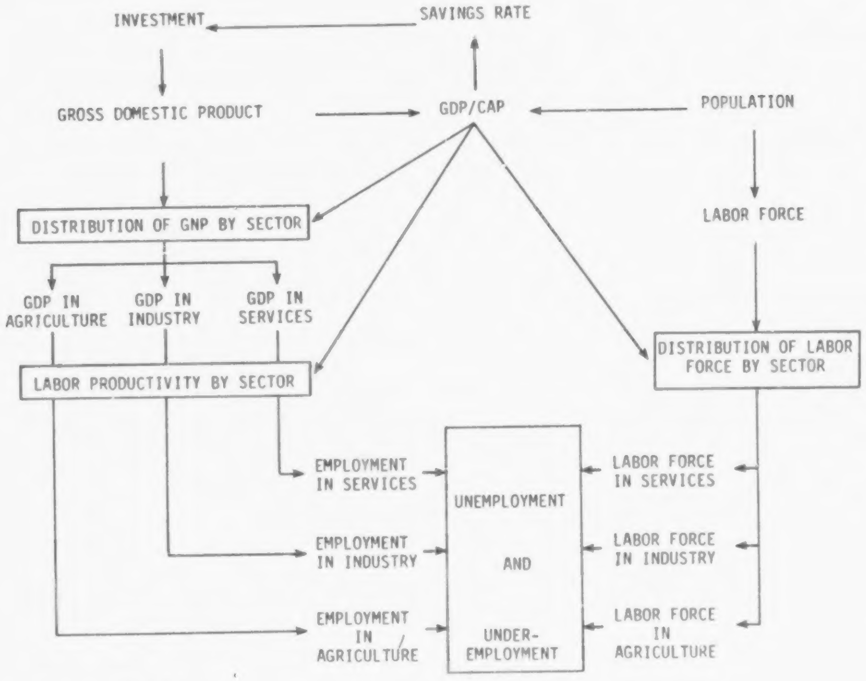

Fig. 14. Model outline.

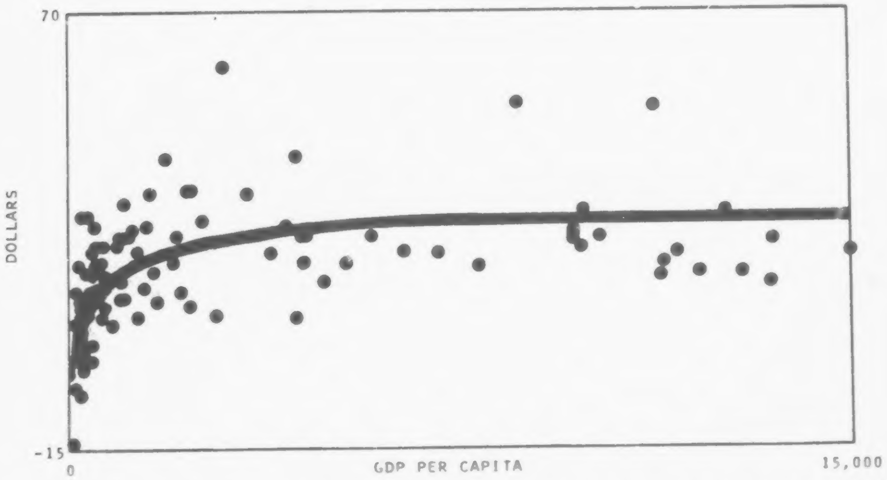

Fig. 15. Savings as a percent of GDP vs. GDP per capita: $Y = -83 + 23.41 \times \ln(\mathrm{GDP/CAP}) - 1.22 \times \ln(\mathrm{GDP/CAP})^2$; $R^2 = 0.41$.

5. Calculate GDP/capita

$$\text{GDP/capita}_t = \text{GDP}_t/\text{POP}_t.$$

6. Calculate labor force

$$\text{LF}_t = \text{POP}_t \times \text{participation rate}.$$

7. Calculate the percent of labor force in each sector

$$\%\ \text{LF}_{\text{sector},t} = f(\text{GDP/capita}_t).$$

8. Calculate the labor in each sector

$$\text{LF}_{\text{sector},t} = \text{LF}_t \times \%\ \text{LF}_{\text{sector},t}.$$

9. Calculate productivity by sector

$$\text{PROD}_{\text{sector},t} = f(\text{GDP/capita}_t).$$

10. Calculate the percent of GDP in each sector

$$\%\ \text{GDP}_{\text{sector},t} = f(\text{GDP/capita}_t).$$

11. Calculate GDP by sector

$$\text{GDP}_{\text{sector},t} = \text{GDP}_t \times \%\ \text{GDP}_{\text{sector},t}.$$

12. Calculate employment by sector

$$\text{EMP}_{\text{sector},t} = \text{GDP}_{\text{sector},t}\ /\ \text{PROD}_{\text{sector},t}.$$

13. Calculate unemployment by sector

$$\text{UNEMP}_{\text{sector},t} = \text{LF}_{\text{sector},t} - \text{EMP}_{\text{sector},t}.$$

The average annual GDP per capita for all developing countries was about $600 in 1980. The average rate of population growth for these countries over the next 20 years is assumed to be about 1.9%/year. If we adjust the model to produce GDP growth of about 5.2% per year (the current World Bank projection) then GDP per capita would grow from $600 to about $1120 by the year 2000. In this case, we would see a 15% increase in the agricultural labor force, but only a 6% increase in agricultural employment, leading to an increase in agricultural unemployment of 40%, or 76 million people. The situation in industry and service is quite different; the unemployment rate decreases by 3% over this period. The industrial and service sector labor force grows almost 90% from 1980–2000, much more rapidly than the agricultural labor force, but from a lower base. The net result is an increase in the number of people unemployed by 60%, or 220 million people. Of course, most of these people will not be entirely unemployed, but they will be in a condition of severe underemployment.

Now suppose we look at the situation with an increase in the rate of growth of GDP of 6.5% per year. In this case, development, as measured by GDP per capita, would proceed more quickly, reaching $1460 by 2000. The unemployment rate would increase even more in agriculture and decline somewhat more in industry and services. The net result would be about 7 million more unemployed by 2000. Thus, GDP per capita would be 30% higher by 2000 with this higher economic growth rate, while unemployment would also be higher, but only by 1%. If we reduce GDP growth to 4.2%, then by 2000 unemployment would be 2% less but GDP per capita would be 16% less.

As a second alternative, suppose we look at the case of even more rapid introduction of productivity-enhancing technology than has been the case in the past. The immediate effect on employment will be negative as more labor-saving technology is adopted. However, increased productivity should lead to higher incomes for those who remain employed. Since at low levels of income savings rates tend to rise with incomes, the net effect should be an increase in savings. Increased savings should lead to more investment and faster GDP growth. Will this faster GDP growth be enough to provide employment for those who lost their jobs because of the adoption of labor-saving technology? According to the model the answer is no. A productivity increase of 20% over the base case would lead, by 2000, to an increase in the savings rate of only about 2%. The result is a GDP per capita that is 1% larger in 2000 but unemployment that is 40% higher. These results are summarized in Table 1.

Thus, current trends indicate that the net effect of increasing productivity in the developing world is to increase incomes for those working but to decrease the percentage of the labor force that is employed. This increase in productivity per worker is the only way in which per capita incomes will eventually rise; however, it appears that, at least in the short term, increasing unemployment will be the cost of that development.

Figure 16 shows the labor force growth rates expected over the next two decades in many individual countries. The highest growth rates will occur in the countries of Africa and the Middle East, where growth of 3–4% a year is expected in many countries. These countries will be hard pressed to provide employment for the large numbers of young people entering the labor force each year. The situation should be less severe in many of the countries of Latin America, where labor force growth rates will be lower.

So, in summary, where does that leave us? Recognizing that the model we used is a vast oversimplification and that important country-to-country differences exist, our analysis suggests the following:

TABLE 1
Summary of Model Runs for All Developing Countries

Run	Assumption		1980	2000	Difference from Base Run
Base run	GDP growth = 5.2%/yr	GDP/CAP	$600	$1120	——
	population growth = 1.9%/yr	unemployment (millions)	350	570	——
High growth	GDP growth = 6.5%/yr	GDP/CAP	$600	$1462	+30%
		unemployment (millions)	350	577	+1.2%
Low growth	GDP growth = 4.3%/yr	GDP/CAP	$600	$ 942	−16%
		unemployment (millions)	350	559	−1.9%
High production growth	Productivity by 2000 is 20% higher than base case	GDP/CAP	$600	$1135	+1%
		unemployment (millions)	350	800	+40%

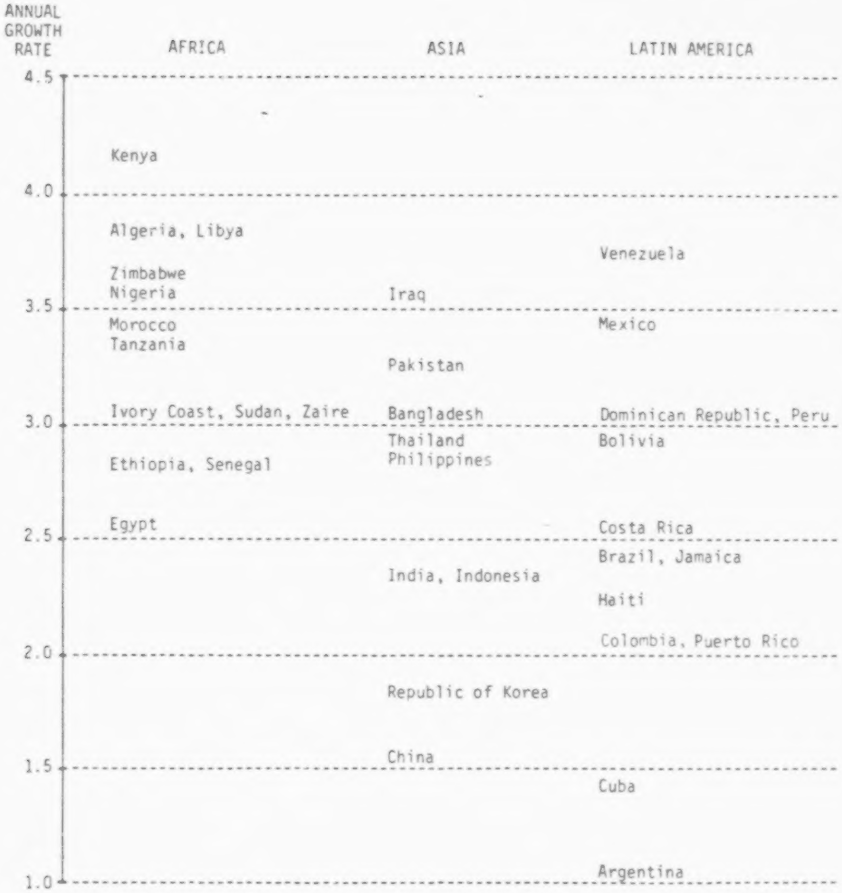

Fig. 16. Labor force growth 1980–2000. ***Source: GLOBESCAN II*** **(The Futures Group, Glastonbury, Connecticut, 1982).**

The current trends in productivity-related technology will lead to increasing unemployment in the agricultural sector. Although labor needs will be rising in other sectors, these needs will not compensate for the labor oversupply.

Economic growth targets and the policies by which those growth targets are pursued may have to consider employment effects more explicitly.

It may be necessary to make efforts to increase employment generation even if it slows the pace of development in order to reduce the extent of absolute poverty caused by underemployment.

New agricultural policies designed to maximize agricultural employment may be useful in many countries, not only from the standpoint of food production, but also as a solution to the looming problem of unemployment.

Without continued control of population growth rates, the situation will get worse.

Received 7 February 1982

Mr. **Bedell**. Our final witness is Mr. Clyde Helms, and we are going to have to get out of here by 12 noon. Mr. Helms.

Mr. **Helms**. Yes.

Mr. **Bedell**. We would appreciate it if you would try to summarize as much as you possibly can. In fact, we are going to have to get out by 12 noon, I guess.

TESTIMONY OF W. CLYDE HELMS, JR., PRESIDENT AND FOUNDER, OCCUPATIONAL FORECASTING, INC.

Mr. **Helms**. I have been deleting sections of my testimony already.

I would like to note that I am president and founder of Occupational Forecasting, Inc. While the preceding testimony seems focused mostly on robots, my firm is concerned with all new high technologies.

I should like to have the opportunity following this testimony, if time permits, to show the committee some of the new occupations we have developed in the broad compass of new high technology industries, sciences, and arts.

I feel a major area of your concerns about the economy must be people, specifically the education, training, and employment of people. Accordingly, my testimony will describe failures of Federal departments' programs on which your oversight concerns might be focused and critically needed improvements affected. We have heard much discussion about the statistics provided to this committee. Information presented here in my testimony has been obtained from civil servants, many of whom have expressed concerns about continuance of programs that do not serve the best interests of the country effectively.

While much has been written about the shortage of competent workers in major corporations, the Congressional Joint Economic Committee and recognized authorities in our universities have estimated that from 60 to 70 percent of the new jobs created in recent years have been in small firms. I am sure the importance of that information will be noted by this committee. Whether large or small corporations, the impact of new technologies, sciences, and arts sweeps across all occupations.

I cannot conceive of any present occupation that hasn't been affected in some way by technology change. Some of my contemporaries predict that the manufacturing industries will follow the decline of agriculture from 70 percent of the work force in the late 19th century to approximately 3 to 4 percent today.

A professor at one of our universities involved substantially in robotic research has been quoted as predicting this decline in manufacturing industries will occur by the year 2010.

Manufacturers of automated office equipment have advised that office automation will impact the jobs of tens of millions of white collar workers. Others predict this will be as high as 70 percent of the white collar work force.

Mr. **Bedell**. I want to hear your testimony, but I do need to speak to someone for a minute. Could we recess for about 1 or 2 minutes here, Mr. Helms?

Mr. **Helms**. Do you want me to stop for a minute?

Mr. **Bedell**. Would you, just for a minute? I will be right back.

Mr. **Helms**. Sure.

[A brief recess was taken.]

Mr. **Bedell**. I think I should probably check this before we start. Mr. Gordon, I presume that productivity would also make a significant difference in your figures? Is that correct?

Mr. **Gordon**. Oh, absolutely.

Mr. **Bedell**. You projected 1.5 percent increase in productivity. As I understand it, we have had almost no increase in productivity recently as well, is that correct?

Mr. **Gordon**. It has just begun to turn upward, just recently.

Mr. **Bedell**. OK, so I am just trying to put them in perspective. If productivity increased the same as GNP, we would be in terrible trouble again, wouldn't we?

Mr. **Gordon**. Higher productivity means greater output and less room for employees.

Mr. **Bedell**. You said 2.7 percent GNP and 1.5 percent, and your projections were that productivity increased about half as much as GNP increased roughly, and if that were not the case, I presume we would also be either in much better or worse shape, depending on productivity?

Mr. **Gordon**. I might just add, if I may, that 1½ percent productivity increase is a middle of the road hope.

Mr. **Bedell**. Thank you.

I am sorry, Mr. Helms for the interruption, but I needed clarification of some points. I really am interested in what you have to say and I would ask you to proceed.

Mr. **Helms**. Well, as I was observing, a recent issue of Business Week predicts the practical elimination of corporate middle management. It identifies major corporations in which such reductions in the white collar work force have already begun.

There will be a significant impact on employment statistics as these middle management white collar executives now join the blue collar unemployed workers at the unemployment offices. I feel the impacts of office automation will be more extensive than the impacts of new production technologies in our industries. The white collar work force is far more numerous than the blue collar component.

In the history of labor and industrial change, populations have resisted major advances, or changes in the workplace. Today the economic viability of the Nation is at stake.

A fully informed public is essential to our success in exploiting the benefits that could derive from maintaining our industrial preeminence worldwide. I hope the information presented here will be helpful to the committee in that respect. The change taking place today is imperative if the Nation is to recognize and cooperate fully in meeting the demands that such changes place upon us. My testimony provides substantial detail and supports my criticisms here of the Departments of Labor, Education, and Commerce. Their failures have contributed more to declines in the American work effort, productivity, and quality of American workmanship than any other definable situation or condition.

A major focus of this committee should be the performance records of these departments and oversight conditions described in this testimony. The economic penalties incurred by and facing our Nation today can be attributed substantially to our failures in development, employment, and management of our supposedly most valuable resource: human beings. The record is clear to anyone who will look critically and objectively at the facts I will present in the following. Today the Nation stands in serious competition with all industrial nations, nations whose economies and employment are as seriously impacted as our own, and in some that are more severely impacted. Economic viability is a critical stake. The degree of success achieved today will determine the ways of life for many nations in the next century, yet our occupational infrastructure has been overtaken by the sweeping accelerating rate of technology change. The Nation's work force is obsolete, or at best obsolescent.

While "there are jobs out there," as the President has advised, the national work force is not prepared to perform these new jobs. The National Commission on Excellence in Education describes some of the conditions most luridly. This testimony explains some of the reasons. It is essential that we undertake a national program to upgrade and rebuild the work force to meet the standards and requirements of the 21st century work force, less than 17 years away.

We must recognize that the inexorable change pressing upon the Nation is the first wave of the 21 century work force. That work force will not be born in some Cinderella-like magic at 12:01 on January 1 in the year 2001. It is being forged today in the robotic factories and new computer-aided design systems, computer-assisted manufacturing plants, and genetic engineering and biotechnology firms, in the new era of photonics and completely integrated undifferentiable communications and computer networks.

To rebuild, we need relevant data.

What information do we have with which to rebuild our work force?

The Department of Labor's "Dictionary of Occupational Titles" is the keystone of the Nation's occupational infrastructure. It is the source of occupations listed in the Department of Labor "Occupational Outlook Handbook" and occupations that may be included in the "Nation's Industrial Apprentice Training Programs". It is obsolete. The new occupations for the new high technology work force were not been included in the last edition, and are not included in the "Occupational Outlook Handbook" or the "Nation's Industrial Apprentice Training Programs". Under present AOL operational procedures, such new occupations may not be included in these authoritative handbooks for some time, if ever.

And if ever, it will take congressional action to make this possible. The dictionary contains 28,000 occupations. Of these, 12,000 are defined, albeit some going back almost to colonial yesteryear. Eight thousand are titles without definitions but which in some mystical way relate to the 12,000 defined occupations and the remaining 8,000 occupations are titles only.

The fourth edition is dated December 1977. More technological displacement has occurred since that edition than in any period in history: Approximately 11 million people are unemployed. Yet those occupations in which the jobs are gone forever remain in the dictionary and the "Nation's Education and Training Programs."

Previous and recent graduates of such programs extend the unemployment lines at the employment service offices in all of our major cities. The dictionary is the authoritative reference used by public service employment offices and in Government programs such as CETA and its successor, the Jobs Training Partnership Act.

It is the basis for the job bank operation specified in the CETA and the JTPA. Employment service offices cannot place unemployed workers in new occupations in the absence of listings of such new occupations. Employers search for high tech qualified workers that aren't being produced under these conditions and may not be available in time to preclude serious economic setbacks for these new high tech corporations.

How many of the 28,000 occupational titles are obsolete? How many are current? No one knows. DOL staff have advised me they have no directive or administrative methodology for identifying or eliminating obsolete or obsolescent occupations.

I have provided in my written testimony a set of terms used by my firm in identifying obsolete, obsolescent, current, emerging, and emergent occupations. I urge these or similar classification terms be incorporated in a national project to assess the "Dictionary of Occupational Titles" and those used in the "Occupational Outlook Handbook" and the "Nation's Apprentice Training Programs."

Working with obsolete occupations is a poor way to commence building a new work force, or upgrading the Nation's education and training program as recommended by the National Commission on Excellence in Education.

The "Occupational Outlook Handbook" forecasts employment opportunities, and numbers of jobs by occupations listed in the dictionary. This handbook is a primary reference used by teachers, career guidance counselors, and employment service staffs. The number of jobs forecast is derived in part from the Department of Commerce current population survey statistics. How useful are these statistics? These statistics are developed in monthly surveys of approximately 58,000 households. Approximately 60 percent are made by telephone calls. Potentials for serious error in collecting these statistics are extensive.

Populations Survey Unit employment and unemployment statistics are based on approximately 400 groupings of occupations, none with definition. Attempts have been made to correlate these occupational titles to the "Dictionary of Occupational Titles."

These statistics are used by the Bureau of Labor Statistics in estimating the numbers of jobs available, and are published in the "Occupational Outlook Handbook," and in employment and unemployment statistics furnished to the Congress.

Following my briefing for some members of the Congressional Joint Economic Committee, the opinion was expressed, "Garbage in, garbage out." The many failures in correlating these occupational statistics have been documented in special studies by Commissions, some going back for decades.

Yet these are the statistics used by career counselors to guide the Nation's youth into occupations for which there is no long-term employment requirement. It is difficult to see how the National Commission on Excellence in Education goals can be achieved given these conditions.

The Department of Commerce has developed a standard occupational code which relates occupations to the standard industrial code. However, staff advised me that SOC does not assure validity of the occupations included in these codes. Surely the value of such system to industries should be investigated. The Department of Education Office of Vocational and Adult Education prepares and distributes vocational education coded data.

Here too attempts to correlate that educational information to the "Dictionary of Occupational Titles" has been unsuccessful for years. How can this system accurately relate educational requirements to occupations in the DOL dictionary?

What occupations? Can the system be of value in achieving the goals of the National Commission on Excellence in Education? I would say the Vocational Education Codes and Dictionary of Occupational Titles will hinder achievement of the National Commission recommendations.

The Congress mandated establishment of a National Occupational Information Coordinating Committee. It would appear from the failures described here, there has been little success in coordinating these incompatible sources of occupational information.

The State occupational information coordination committees and similar coordinating committees in some of the larger cities are similarly affected by failures of the national level occupational information networks.

As in the Department of Commerce Standard Occupational Codes, the Federal, State, and local coordinating committee pipelines process information of questionable use and may even be penalizing unnumbered thousands of unemployed workers with misinformation and guidance.

I agree with these staffs that the coordinating committees could possibly serve a useful purpose if current valid labor market information were available. It is not.

That does not seem possible under the conditions I have described in the preceding comments. The lack of useful information compromises the work of Government staffs at all levels. These costly bureaucracies and overlapping data systems are used by many other organizations and researchers in the private sector.

I would like to add here after looking at the statistics in the Upjohn Institute study, the researchers compiling the statistics for that study—which has been discussed here this morning—must have found Government statistics leave much to be desired. I cannot endorse the statistics in that study.

While this study represents one of the most well-reasoned efforts of researchers today, it encountered the same type difficulties as Government analysts, wherever researchers found it necessary to depend upon Government statistics.

Occupational statistics derived through these Government systems do not provide, one, sufficient, two, specific, three, definitive, four, accurate, and five, current statistics.

Such difficulties as confronted those who have testified here today evidence a problem of national dimension and consequence. The fact is that we do not have urgently needed information on new high technology occupations, nor reliable statistics on even present occupations and employment opportunities.

The DOL staff have advised me: They have never created a new occupation; they do not know how to create new occupations; and, they question whether they have the statutory authority to do this.

Accordingly, there appears to be no way in the Federal Government or the private sector to identify the needs for new occupations and to create such occupations.

In the absence of such information, employment services offices cannot be expected to place unemployed workers in the new occupations being generated by high technology firms, and education and training organizations cannot set up appropriate new occupations training programs.

I urge this oversight committee to address these with such urgency as it deems appropriate. It is particularly urgent today that action be undertaken quickly.

Staff in every State are now planning to implement the Job Training Partnership Act. If the States and their private industry council set up training and retraining programs in sunset occupations, more billions of dollars will be spent in a massive national recycling of CETA failures.

Exhibit 2 of my written testimony lists some new occupations selected from my occupations data basis. Some of these occupations have been published in the Washington Post, the U.S. News & World Report, the Chicago Tribune, and other leading newspapers and news weekly magazines, and have been shown on national television and presented by me in seminars and JTPA workshops in a number of States.

I have designed other occupations in new technologies, sciences and arts in which potentially millions of new jobs could be created before the end of the century. To the best of my knowledge, Occupational Forecasting, Inc., is the only such firm in the country. Other countries have corresponded with me and requested information about this new emerging science of occupational forecasting. Surely a new approach to occupational assessment and forecasting and creating new occupations is urgently needed in the Nation's interest. At this stage of my work, it appears that private sector organizations are ready and eager to undertake this work.

Nevertheless I urge this committee to give consideration to establishing a national project on a priority basis to advance the uses and benefits of such techniques and methodologies as I have pioneered. Failure to do so can be most costly to the Nation. Some modest projects have already been undertaken in one major city and others are being seriously considered in other States.

Additionally, a methodology is available to facilitate such proposed national undertaking. The first successful experiment in the private sector to develop new occupations was funded by the Department of Labor Office of National Programs.

An evaluation of that national model is excerpted from their letter to me as follows:

> We believe that the model has shown itself to be successful and adaptable to other occupational areas. As you may know, in addition to other activities, the Office of National Programs funds programs with a special nature or bearing upon national employment problems.
>
> The model programs you participated in developing fall within this category. The purpose for supporting most such efforts is that they may have some replicability in the State and local employment and training systems.

Within this context, we believe that the model education and training delivery system has been shown to be effective and is available to others who would wish to use it.

Further, we feel that the model lends itself to a variety of occupations and that potential users can make necessary adaptations accordingly.

As you can see from this testimony, we have a need to create new occupations. This need is not being met, the model has never been replicated. I will now show quickly, if I may have the privilege, some of the new occupations which we have forecast. We can implement these new occupations through this model.

In concluding my testimony, I would like to quote an economist of a previous era and I would suggest that the committee and the Nation today might take guidance accordingly.

Arnold Toynbee once described the rise and fall of nations under conditions similar to conditions confronting our Nation today. He said:

> A young nation is confronted with a challenge for which it finds a successful response. It then grows and prospers. But as time passes, the nature of the challenge changes, and if a nation continues to make the same once successful response to the new challenge, it inevitably suffers decline and failure.

[Mr. Helms' prepared statement with attachments follows:]

PREPARED STATEMENT OF W. CLYDE HELMS, JR., PRESIDENT AND FOUNDER, OCCUPATIONAL FORECASTING, INC.

Mr. Chairman, Members of the Committee, my name is W. Clyde Helms, Jr. I am President and founder of Occupational Forecasting, Incorporated. I wish to thank you for the invitation to present this testimony, and the opportunity to present to this Committee what is perhaps the greatest challenge in the history of education, employment and training.

While the nation struggles to cope with the overwhelming effects of high technology, high deficits, record unemployment and increasing costs of socio-economic programs, the Congress produces new education, jobs, and unemployment benefits legislation treating with the affects rather than the causes. In this testimony, I will urge The Congress to correct situations within the federal government which contribute to economic disarray throughout the nation - particularly in major cities and industries. I will focus upon three departments in the Executive Branch - The Departments of Education, Labor, and Commerce. The responsibilities of these departments bear directly upon the education, training, and employment of the national workforce and the ability of the nation to compete effectively in world trade and commerce.

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The august Council of Economic Advisers and other economists who advise the President and the Congress admit they do not know enough about employment and unemployment. Yet, they attempt to resolve the nation's most critical problem exclusively through manipulations of the nation's financial systems. Such financial manipulations alone cannot achieve a correct solution. Recognizing that industries which are directly supported by government subsidies, subtle forms of import restrictions, and directly funded research and development projects have advantages over U.S. industries, I believe a vigorous, productive U.S. workforce will offset significantly these governments' capitalized industries. There is a limit to how much and how long even governments can compensate for industries that are not as cost effective as U.S. industries. If we can correct the mis-management of our human capital, that will be the most significant element in regaining our economic strengths.

> Arnold Toynbee once described the rise and fall of nations under conditions very characteristic of the challenges to our nation today. "A young nation, 'he said,' is confronted with a challenge for which it finds a successful response. It then grows and prospers. But, as time passes, the nature of the challenge changes and if a nation continues to make

the same once successful response to the new challenge, it inevitably suffers decline and failure."

I will describe some of the human economic challenges confronting us today, and the consequent penalties - or successes - depending upon the nature of our response. The challenges to this Committee are for major changes in the three Departments noted above.

- PART I - DEPARTMENT OF EDUCATION -

A major cause of the economic problems facing the nation today is occupational obsolescence. The national workforce is obsolete. Sweeping, accelerating changes in technology and science have impacted every occupation in the nation's occupational infrastructure. The greatest impacts are yet to come, before the end of this century. Evidence of such great change is clearly visible in the multi-billion dollar federal and private sector research and development programs, the emergence of new industrial technologies, sciences and arts; the decline of basic industries, unfavorable import/export ratios; and record unemployment. No one familiar with the implications of these events will disagree that technological change will affect every occupation, at every level from laborer to the highest professions. As Lloyd Dobyns stated in the conclusion of the NBC TV Award winning white paper, "America Works When America Works," - "It isn't change so much, it is the speed of change!" I urge this Committee to assess the need for a priority national project to identify and to publicise "sunset occupations" and to replace these with new "sunrise occupations." Change is imperative for the nation's economic survival today and in the future. Some organizations may seek to delay these imperative changes - make industries and other employers retain employees in obsolete occupational classifications and at wages established over decades. The nation must recognize that the change Mr. Dobyns alluded to is the inexorable pressure of the 21st century workforce - only 17 years away.

Historically, structural changes in the workforce have evolved over decades. There isn't time for such evolution today, a new national workforce must be designed, engineered and emplaced as soon as possible. Such challenge has never occurred before. The 21st century workforce will not occur in some "Cinderella-like magic" at 12:01 on January 1, in the year 2001; it is being forged now in the new Computer Assisted Manufacturing (CAM) plants; in the engineering departments of Lockheed, General Motors and General Electric and Fujitsu Fanuc where Computer Aided Design (CAD) is creating radical changes in the ways engineers design, engineer and layout new products; in the Flexible Manufacturing Systems and Flexible Manufacturing Cells (FMS/FMC) of the nation's major manufacturing plants; in the automated office, or office of the future. Truly, the speed of change is overwhelming the bureaucracies of the government and private industries. No important occupation will ever again be current for more than two years. How can the nation respond to the challenge of constant change?

Technology half life is no longer a comfortable 5 years - perhaps 2 years in some technologies. What does such sweeping change imply for the nation's educational and training institutions? Does anyone know? Where are the assessments and impact studies? They do not exist. The nation is grossly unprepared! Yet, the challenges and opportunities have never been greater - or more imperative. As the currency of occupations is now limited to two years -- all education and training programs must be placed in a state of continuing revision and updating. This Oversight Committee should assess the accuracy of that statement and its economic implications. Will we insist that our education and training systems and institutions assume a major responsibility and accountability for development of a cost-effective workforce?

Can textbooks be updated and maintained current with such accelerated changes in science and technology? I am confident everyone will agree - the answer is an emphatic no. Some publishers have advised me that they cannot obtain new technological information in a timely manner. When they get such information, it is two to three years, or more, behind the current state of the art, or technology. When they get such information, they have difficulty finding a writer expert enough to write the new textbook. Writing the book takes about a year, another year is required for marketing the book and two or more years to get it onto the bookshelves and in libraries, and even longer before it is incorporated into curricula. Thus, it is rather clear - in this illustration - why we have been advised by our foremost competitor, Japan, that we "...should have started 30 years ago." (Advice given some of our industrialists on how we might catch up with the Japanese.)

However, the technology which is creating such demands upon education will also help with solutions. While computer assisted instruction has been around for some time, computers and software now being used in industry and in the automated offices provide new dimensions and techniques for use in vocational and technical training. I have conferred with entrepreneurs who are already at work on designs for new equipment that will revolutionize the practice of human instruction and teaching. Some of the new occupations my firm has forecast for the education and training establishment seem more like industrial occupations - yet, with artificial intelligence, and CAD/CAM like equipment, great changes in education and training are in sight.

We have seen the rapidity with which popular songs can be taped and mass marketed. And we are intrigued by the intensity of interest shown by young people spending their allowances and earnings in the Atari arcades. Major corporations are now vying for the new market in educational materials. Audio-visual instructional cassettes can be produced rapidly in great quantities and updated at less expense than books. Expertly planned and programmed instructional materials are being developed that will free teachers from many of their teaching duties in overloaded school rooms. Students in all levels of education will work (one-on-one) with sophisticated "learning machines." Such teaching and learning machines will enable the nation to better meet the needs of the new high-tech work forces of today and the 21st century. The quality of education and training will go up; costs will come down. As a pioneer in computer assisted instruction, and the biggest employer and trainer of workers, the Department of Defense might provide national leadership in promoting the use of these new "learning machines."

I recommend to the Committee that conferences with the DOD be undertaken on a priority basis. Improvements in DOD training and the cost reductions that could be achieved by DOD would surely warrant serious consideration at the Secretary or Assistant Secretary level. These benefits can be extended beyond DOD by including teams from the Departments of Labor and Education and public and private sector schools.

It should be clear to this Oversight Committee that professors, teachers, instructors, and trainers must be among the first to go back to school, or to gain experience in the research laboratories, computer managed plants, and automated offices. Are they sufficiently expert in the new technologies, sciences and arts? Do their graduates go into essential, long term occupations, or, to the unemployment offices?

As a part of a national assessment, the Committee should note that programs, curricula, and textbooks should be assessed for currency. It does seem ridiculous to perpetuate education and training programs for obsolete or obsolescent occupations - at whatever level. Nevertheless, these instructional programs and materials will probably continue producing educated and trained persons for "sunset occupations" throughout this century. The nation cannot accommodate to this possibility.

While accelerated change in our educational institutions and programs is urgently needed, credentialing requirements will deter such progress. National accreditation associations and regional accreditation associations must accelerate their reviews and approvals of new degree and certificate programs. Again, lack of familiarity with the character of technology change will inhibit these associations. However, the nation can no longer afford the deterrent effects of time consuming reviews of proposed new degree and certificate programs. The very principle of awarding degrees and the values of such instruments may be shunted aside as imperative pressures compel employees and employers to concentrate upon courses and programs that enable them to remain abreast of actual employment requirements. As in educational administration, personnel administration and industrial relations staffs must now accomplish extensive revisions in all elements of their work. Education and qualification, wage and salary, and performance standards are no longer realistic. This is a critical requirement in meeting the high costs of employment. Penalties are already well evidenced in the loss of low cost jobs to other nations.

I have recommended a national assessment of programs, curricula, and textbooks. The Committee should give consideration to including assessments of the nation's credentialing requirements and the familiarity of credentialing staffs with the new world of work. Numerous articles published in some of our foremost journals are raising these questions. And while a national debate is predictable, it isn't difficult to predict that new education and training programs will not be held back while academicians and theoreticians debate todays values of yesterdays practices. Nevertheless, new means of upholding our traditional excellence must be devised.

To illustrate the point, my firm has conducted technology assessments of some of the new high tech industries, automated offices, genetic engineering breakthroughs, and other exciting developments of high technology and science. We have identified new occupational fields in which potentially many hundreds of thousands of jobs could be created. Recognizing the difficulties in credentialing systems, we have titled these new occupations as Technicians or Specialists. Though college level credit courses will be required in all of these technician occupations, I feel the new courses in new technologies, sciences, and arts must take precedence over some college courses required for degrees. Accordingly, we are recommending to educational and training institutions that concentration be upon the essential work-related courses, and while employed in these new occupations, the employees may take additional courses needed for the degrees. Hopefully, the Committee will raise the question - yes, but how long will it take to make all credential course work more closely related to the workers' constantly changing educational and training needs? Identification of obsolete and obsolescent occupations should facilitate such desired eventuality.

The Committee will recognize that the technological renaissance affects the nation's educational and training systems as much as it impacts industries, business, and commerce. The results of industry "sunsets" and "sunrises" carry portents as serious for educational establishments as in industries. Only those universities benefitting from large research and development funds can adjust to meet the challenges of technology change. It would seem there should be a requirement that these universities provide information on their research to other educational institutions in a useful manner - including perhaps assessments of the impacts of new R&D breakthroughs on existing curricula.

Teaching professors and staff members cannot be expected to be sufficiently familiar with such new research and development accomplishments as to be able to prepare new curricula and to teach such developments. Arrangements should be made so that teaching staffs either visit or participate in the research and development work at universities where such work is well funded. If the authority for promoting such activities on a timely and effective basis does not exist at the Department of Education, perhaps The Congress should provide such authority. It seems that the National Institute of Education might take this matter under consideration, as well as other matters discussed here. Perhaps these challenges of the 21st century workforce exceed the authority and capabilities of the Department? Can the Department meet this challenge? I feel the

Department - as organized and staffed cannot meet these challenges of the 21st century workforce. Rather, I have recommended that eminent leaders in our educational institutions convene a national conference to address these and other related matters and develop a new order that will endow institutions of higher learning with more independent authority and funds to act directly and indepently or in cooperation with others in responding to the needs of the nation.

Slow moving bureaucracies, in the governments and in the private sector, cannot meet the challenges of such dynamic events today. The National Science Foundation has expended many millions of dollars for educational grants. Some who administered those programs admit it is difficult to identify direct benefits. The Congress should consider how to promote independence of the universities and help these institutions to exercise their private initiative in meeting the nation's urgent needs. Their continued dependence upon and regulation by federal departments will result in serious penalties for the nation and the people. The present educational establishment, overall, is as poorly prepared to meet the challenge of the 21st century as the nation was prepared militarily for the attack on Pearl Harbor. Today, it is the economic viability of the nation that is at stake.

A new high tech work force will enable the nation to prosper and enjoy its investment of billions of dollars in new high tech industries, business, and products. Creating a new workforce is the greatest challenge ever to the vocational education and training establishment - public and private sector. The President has submited proposals to The Congress in which parents would be better enabled to pay for education in private institutions, or public institutions according to their determination of which better meets the needs of their children. With the future of the nation and each individual more dependent than ever upon the availability of a broad range of quality education and training programs, individual decisions on how to use available resources should be encouraged in line with one's responsibility for their career success. This Committee should consider whether the educational establishment has met its responsibility to the nation and whether federal departments can function sufficiently well in these respects in an era of continuing technology change. To what extent, if any, should the activities of the Departments of Labor and Education be turned over to the private sector? An unemployed workforce of approximately 10 million people, would seem to demand immediate action.

Vocational training in public schools seldom compares well with that in private vocational schools. The importance attached by public school officials to this form of career development leaves too much to be desired. Vocational training must be seen in a more important role. The competency of the nation's workforce is a critical element in international trade - isn't it time The Congress recognized this fact and acted to bring this economic element into the economists' calculations and theories? Like investments in industries, investment in vocational and related training should be viewed in capitalization plans and measurable benefits. It is time for employers to place accountable values on human capital and to account for their usage and investments here as they do for other assets.

Costs of vocational training on new high-tech equipment and systems will increase substantially. Complex, sophisticated equipment, materials, and processes are costly. I question whether at the secondary or the two year junior college level, the costs of such equipment and competent instructors can be borne. Equipment used continuously for technical training has a high failure rate. Costs of replacement parts add to the costs of training. Warranties generally do not apply to equipment used for training purposes. Again, given the speed of technology change, this expensive equipment will quickly become obsolete. Much of the equiment now in the vocational schools is already obsolete - some of it dating back to World War II. The Committee should consider the costs to the future workforce of training youth and new entrants on equipment of the mid-industrial revolution era. One computer manufacturer has recognized this problem and offered to provide a computer to each school; other computer manufacturers are now making the same proposals. The Committee should consider this unique evidence of the values employers place upon vocational training. Worldwide sales of microchips are forecast to surge from $14 billion in 1981 to $27 billion in 1985, and $100 billion by the year 2000. Jobs for computer programmers have been forecast as increasing by 10,000 a year through 1985. When one considers the "economics of big business" - such as computers, communications, genetic engineering and biotechnology, and robotics - the essential interdependence of human capital will be factored into economic and financial formalae. I urge this Committee and perhaps the Congressional Office of Technology Assessment to provide the leadership in developing new principles for weighting human capital in technology and industrial finance.

For too long, The Congress has appropriated billions of dollars in actual funding and tax benefits to promote the advancement of science and technology research without requiring assessments and cost-benefits analyses of the resultant effects upon the workforce. Surely, the Japanese have shown us the folly of such oversight, for it is U.S. science and technology they have exploited in seizing so much of world commerce; including notably heavy inroads into business and commerce right here in this country. Our vocational training institutions and programs must exemplify all the qualities that we expect in our industries. If pride in work and productivity in our industries are to match, and hopefully, exceed that of the Japanese, then these qualities must be inculcated during the training of the new workforce. It is a sad reflection of our once greatness that educators and industrialists from this country now journey to Japan to learn from their educators and industrialists and return and proclaim that they are setting up "Quality Circles", and adapting other principles of Japanese expertise.

Though I am severely critical of the federal departments, it should be quite evident that their oversight reflects congressional oversight for some years. Governors' employment and training staffs have advised me that without information as to what are or will be the new high-tech occupations, the Jobs Training Partnership Act (PL 97-300) programs can only be a rerun of the Comprehensive Employment and Training Act (PL 93-203) programs and many thousands of trainees will be trained in the same occupations in which many thousands of former employed experts now line up in queues at unemployment offices throughout the country. I urge the Committee to take steps immediately and initiate a national project of occupational assessment and forecasting. Otherwise, we will fulfill in this latter part of the 20th century the philosophy of Arnold Toynbee.

A new beginning, a renaissance for vocational training, is clearly in the interests of the nation and its people. The character of the 21st century workforce will depend substantially upon the character of vocational training. This essential national resource must be protected and promoted with all due recognition of its economic importance. Vocational training is not just a "trade school concept" - it must be accorded the status of higher educational institutions. Doesn't everyone go to school to enrich and to better their lives? Don't lawyers, doctors, financiers, and other "professionals" train for excellence in their professions? But, will funds for "vocational training" ever match funds for higher level education? Perhaps the scientists and technologists on this oversight committee would find some of these comparisons more acceptable if they were backed up by cost-effectiveness studies. I agree that such studies are urgenty needed - but who is producing that information? The Congress has appropriated tens of millions of dollars for educational research. The National Institute for Education (NIE) is well conceived for such important research, as is the Department of Labor Employment and Training Office of Research and Development. In view of the large sums appropriated for adult and vocational education, I urge this oversight committee to investigate the costs and benefits attained by federal departments' expenditures of these funds.

I see no way in the near-time-frame whereby vocational training institutions will have the necessary funds to provide the requisite training in new technologies, sciences, and arts. Costs of new technologies hardware and systems are prohibitively high for these institutions. Obviously, employers must assume a greater role than ever before - it is certainly within their "bottom-line" interests to do so. And, as indicated by previous remarks - many are already moving in that direction. The alternative for employers to provide help to private and public institutions is to do the whole job themselves. Analogously, we may find that vocational training institutions will have to be built in the parking lots of the major corporations. That is the only place where current "hands-on" training can be accomplished on-the-job, working with production equipment and systems.

And, that is one of the salient differences between the CETA and the JTPA. The latter Act provides training funds to employers. Whether in the automobile plants or the intensive care units of hospitals, programs such as work-study and cooperative education appear to be among the most effective ways to meet the constantly changing requirements of a high technology workforce. Changes in vocational training must match changes in the nation's high-technology workforces. Requirements for changes in vocational training will thus be as constant, as intense, and as imperative as the affects of technology changes within our industries.

Is The Congress allocating education and training funds appropriately, in the best interests of the nation? Why are essentially complementary education and training responsibilities divided between the Departments of Labor and Education? Is this cost effective and beneficial? For example, why shouldn't the Office of Vocational and Adult Education (OVAE) be co-located with the Bureau of Apprenticeship and Training (BAT)? Why shouldn't the National Institute for Education and the DOL Office of Research and Evaluation be integrated? Is this separation of education and training research influenced by academic philosophies which no longer obtain, by beliefs that one comes under the purview of educators and the other under the purview of labor? Is it because The Congress perpetuates this ineffectual division in its budgets for the two Departments, or that The Congress cannot take the time and do the work needed to review and re-write Acts that have piled on top of each other for decades? I trust in this testimony I might influence this Oversight Committee and you will conclude that congressional oversight compares with that of the Executive Branch Departments. The following testimony will treat more specifically with definable oversight situations in the Departments of Labor, and Commerce.

- PART II - DEPARTMENT OF LABOR -

The Department of Labor (DOL) publishes the nation's Dictionary of Occupational Titles (DOT). This volume of 28,000 occupational titles includes 12,000 titles with supporting definitions. 8,000 titles without definitions purportedly relate to the 12,000 defined occupations - though no one can define that relationship. The remaining 8,000 titles are without any definition. The DOT is the "keystone" of the nations occupational infrastructure. It is the source of occupations for which the DOL Occupational Outlook Handbook forecasts job employment opportunities, the Bureau of Apprenticeship and Training approves occupations for the national apprenticeship program, and for the Bureau of Labor (BLS) reports on employment and unemployment statistics to The Congress.

The Dictionary is updated and republished decenially, concurrently with the Census. The Fourth Edition was released in 1977. Change sheets are issued or available at unspecified times. It is obviously impossible to insure that such change sheets reach all who have purchased the DOT. Dictionary staff have advised me they have no directive or administrative methodology for eliminating obsolete or obsolescent occupations listed in the DOT. Yet, in the five years since the DOT was last published, more technological change has occurred than ever before. These terms can be of national importance. Without a national classification system, educators will continue to educate and train students, unemployed workers, and others in "sunset occupations" while employers complain about the non-availability of workers qualified in the new technologies and automated offices. It is as important to identify the "old occupations as it is the "new occupations." Exhibit 1 is a set of terminology used by my firm for identifying and assessing obsolete, obsolescent, current, new, and emerging occupations.

Similarly, the DOL staff has no methodology for identifying needs for new occupations in new and emerging technologies, sciences and arts. There is no program in the federal departments or the private sector to forecast and create new occupations. Obviously, the national occupational infrastructure must be replete with obsolete and obsolescent occupations. At the same time, no one knows what are the new and emerging occupations. How can anyone determine how many new jobs - what jobs - are needed? Educational and training institutions do not have urgently needed information as to what are the new occupations.

Exhibit 2 is a listing of some new occupations I have designed and proposed for development. Other occupations have been designed and are being presented to Governors' Employment and Training staffs for use in implementing the JTPA, to Chambers of Commerce Economic Development Administration staffs, to corporate officials, and education and training associations. Most of our new occupations forecasts were presented in a workshop at The National Center for Vocational Educational Research last December. Potentially, millions of jobs could be generated in these new occupations, and additional thousands of essential new occupations could be designed if an active national program could be established for such purpose. I propose this be a collaborative effort by national industries associations working with institutions of higher learning - particularly those benefitting from large R&D funding. At this time, my firm is the only organization in the country doing this work. We have inquiries from a foreign government and correspondence exchanged with another. Proposals for such programs have been submitted to the Department of Labor, and the Department of Education.

Given the rapid pace of changes in industry, commerce, and business, no printed dictionary will ever be current. The nation needs a real time computer based occupational and employment information system. While the New York Stock Exchange can handle and report stock transactions well in excess of one hundred million shares, amounting to many billions of dollars, the nation does not have a system for real time employment opportunities reporting. The Congress has directed the DOL, in both the CETA and the JTPA, to "...establish and carry out a nationwide computerized job bank and matching program...on a regional, state, and local basis, using electronic data processing and telecommunications systems to the maximum feasible extent possible for the purpose of identifying sources of available persons and job vacancies..." The Committee can ascertain that such systems do not exist, functioning as intended by The Congress.

"Job Bank" computers are presently used for storing employment opportunities information gleaned over a period of up to three months, collected by correspondence and through exchange of microfiche records furnished by state and city employment services. A newspaper-like publication - Occupations in Demand at Job Services Offices - sets forth such information. Distribution of this publication cannot possibly meet the demand - even if the information were current and usable. In a personal telephone survey of employment offices in several states, I found that few of the employment staffs were aware of this publication, that some were keeping the occupational information on microfiche file, that job opportunities listed were out of date, and that the sources could not be identified. The publication is a failure; the requirement for a real time occupational information job bank is a failure; compliance with the requirements set forth in these Acts is a failure.

Nevertheless, the need for a real time occupational and employment system network must be met. The Committee should promote assistance by the Department of Defense (DOD). DOD world-wide real time data bases represent a state of the art far exceeding the comparatively simple requirements for a national jobs data bank. The JTPA includes provisions for the DOD to provide assistances If The Congress or the Executive Office of The President were to implement this suggestion, I would estimate two or more years would be needed for implementing such a national system. I believe, as a matter of scale, the NASDAQ Network is comparable to what is required, (National Association of Stock Dealers Automated Quotation). As will be described in the following, the departments have been unable to produce a uniform system of occupational definitions, codes and statistics. It may well be the job is too big and complex, requiring technical systems skills and knowledges not available in these departments. Surely, any further consideration of such networks should include the possible economies and other attainable benefits that could be derived if this system were to be designed and operated by the private sector. As recommended previously, perhaps consortia of industries associations and educational institutions could operate such system.

The inadequacies of DOL dictionaries and dependent publications have been described. Additionally, the Committee should consider investigating the utility of occupational information published by the Department of Education, Office of Vocational and Adult Education (OVAE). Vocational Educational Codes are disseminated through the Vocational Education Data System (VEDS). Why are these codes necessary? Why not use the DOT? Both DOL and Department of Education staffs have spent uncounted hours of effort over a period of years trying to develop a "cross-walk" (correlation) between these codes. The Department of Education staff advised me the problem is compounded when the National Center for Education Statistics attempts to compile statistics developed from differing bases. As in the DOL Occupational Outlook Handbook, the National Center for Educational Statistics produce data to serve the educational establishment. The only recourse conceived by staffs in the departments, and supported by the Congress, is the establishment of a National Occupational Information Coordinating Committee (NOICC). That Committee has extended its statutory mandate by promoting establishment of State

Occupational information Coordinating Committees (SOICC). Yet, the operation of irreconcilable data bases continues without improvement. Obviously, the value of these extensive and expensive networks depends upon the quality of information distributed through the "pipe line." Officials with whom I have discussed this problem generally agree that the rapid pace of technology change today - and as it will be in the future - has overtaken the occupational information now transmitted through this network. If the quality and quantity of occupational statistics and information could be upgraded to meet the needs of today, the NOICC and SOICC could become useful means of transmitting information between offices at this level.

However, another question remains as to how effectively this information would be used by local employment services agencies. The JTPA authorizes funds for labor market information (LMI) research. To the extent that such funds are used to extend present methods of occupational information dissemination, this Committee would be advised to monitor such expenditures closely. Current, valid information on new occupations does not exist.

This situation raises the question of how public employment services offices can match unemployed workers with the "new work, out there." They cannot. One hears so much about "structured unemployment" and while that term has as many definitions as sources that use it, The Congress should recognize that much of the unemployment today is due to the inability of employment services staffs to match applicants with new technology jobs that aren't listed in the DOT, or other government furnished occupational information. Even were current high tech jobs information provided to employment placement officers and counselors, many are unfamiliar with such new technology and cannot interpret such job requirements and relate these to the qualifications of previously employed highly qualified machinists, tool and die makers, electronic technicians and other craftsmen. Consequently, the best way for persons with such technical skills to find jobs in the new high tech workforce is to search the newspapers and professional journals want ads. Many of the new high tech firms have increased their recruitment staffs and displaced workers who have found such employment on their own initiative will advise the Committee there is no comparison of the services and comprehension of state and local employment offices staffs with those of the corporations. Corporate recruiters will probably advise you they do not place requests for recruitment with public service employment offices as the staffs there are unable to understand the highly technical character of positions available. Within a few more years - when the numbers and types of high technology occupations will have increased greatly - one might question whether state and local public service employment offices can be even marginally useful in matching technologies and unemployed persons. The Committee should plan now how to cope with this eventuality. Typically, it is the small businesses - that don't have large personnel departments - which are most dependent upon these employment agencies.

In workshops conducted in several states, I have discussed with educators and officials of major corporations the concept of national industries associations forming occupational information networks in which occupational definitions and employment information would be pooled and processed through private sector clearinghouses. (The Department of Commerce National Technical Information Center is somewhat illustrative.) I wish to advise the Committee there is definite interest in this idea; some of the discussions are moving into the system concept stage.

As mentioned previously, occupational and technological information would be disseminated by associations' occupational analysts. Aggregated occupational and employment statistics would be provided to a national clearinghouse. All of this information would be available on a real-time basis to educational establishments. This assistance would enable institutions to update existing curricula and to develop new education and training programs in a more timely manner. Further, university, college and high school staffs could assist in developing new educational qualifications requirements for new and updated occupations at associations' occupational clearinghouses.

If we can resolve the problem of providing current occupational information to state and local employment services agencies, the Committee should consider how the matching of unemployed persons with new job opportunities can be improved. As noted, it isn't necessarily the qualifications of unemployed persons that determines whether they succeed in getting a job through the offices. The capabilities and interests of employment staffs are a factor. Ways must be identified to bridge this deterrent.

The means are readily available to implement far more effective procedures in which placements of unemployed persons are not dependent upon the knowledge and capabilities of employment counselors. National networks gather news reports from all over the world every evening. Network reporters here in the states interview their reporters face to face in countries and remote areas all over the world. Members of Congress and other distinguished persons are interviewed in their offices, talking with reporters in Washington, D.C., New York, and other major cities. Side by side, face-to-face interviews are presented routinely on the TV screen. This technique could be cost-beneficial if implemented by state and local employment services agencies - within the states, and between states. The video telephone is an accomplished state of the art and within the time to design and implement such vis-a-vis employment interviews, that telephone system could be an integral feature. Whether by the telephone or by present teleconferencing systems, major changes must be made in the present inefficient methods used by public service employment interviewers attempting to place unemployed persons in new jobs. Again, the JTPA provides for research funds to be expended in developing labor market information (LMI). Pilot experiments might be commenced in major cities where reduction of high unemployment rates justify costs of such pilot experiments.

I have attempted to explain why present labor market information is grossly inadequate. To the extent it misleads unemployed persons concerning the long term employment potentials of obsolete or obsolescent occupations, it merely shifts today's problems to tomorrow. Computer dating games do it better. Nevertheless, with electronic employment systems as described here, we can generate the highest potential employment and benefits. Without such systems, unemployment will continue to increase with the advances of technology, science, and the arts.

The national costs of occupational obsolescense are incalculable - perhaps some competent economist can derive acceptable estimates. The ability of the nation to compete with other nations in world markets and even for our internal markets is well described and documented in the media. While the highest officials of nations meet in international summits to discuss trade and all the elements affecting commerce, our basic industries have suffered losses on the order of 30% or more - steel, textiles, electronics are but a few examples. In debates with officials of other industrial nations, and emerging nations, the high costs of U.S. labor has been constantly noted as a primary factor in export/import imbalances. Japan, more than any other nation, has forced us to critically examine the cost of human intervention in all production processes. To compete with Japan's industrial prowess, much of it built upon new production techniques, management, and U.S. products and technologies - the U.S. and other nations rush into computer assisted manufacturing, computer aided design, flexible manufacturing systems and flexible manufacturing cells.

The use of these new production technologies at this time favors the U.S., where leadership in such production systems remains. But, this benefit can be lost if a new workforce is not designed and put into place as quickly as possible and feasible.

The benefits of our research have been extended to all technologies, sciences, and arts. And while the nation's hi-tech revolution has been on-going, the nation's apprentice training programs plod along enrolling and graduating apprentices in crafts and trades of decades past. Where are the apprenticeships for the new technologies? They don't exist. As a former director of Navy apprentice programs, I know that one of the most difficult administration tasks is to insure that apprentice training programs are constantly updated and retained abreast of new technologies. I doubt such administrative pressure is exerted in the nation's industrial apprenticeships. Some of these plans are, perhaps, still printed on mimeograph sheets of years past.

Apprenticeships are a primary source of recruitment and enrollment of union members. The effects of obsolescent apprenticeships may be seen in the heavy losses of union members' jobs - jobs that are "gone forever." But these apprenticeships are continuing. At a time when the Congress has appropriated billions of dollars in tax concessions for the industries to rebuild plants - where is the essential accompanying assistance for the nation's apprentice training programs? Will the Congress permit this essential program to fade into the history of the industrial revolution? In my remarks about vocational education and training, I noted that the high costs of hands-on-training will never again be within the funding range of high schools - or, for that matter even some post secondary education institutions. The apprentice program administered by the DOL is based upon the Fitzgerald Apprentice Act of 1937. Isn't it long past time for the Congress to update that Act? Many of the challenges presented here should be addressed in any such update - or new legislation superceding that Act. Legislation such as the Davis Bacon Act, and the Walsh Healy Act should be evaluated in any new legislation. It does appear that the Congress has for the most part overlooked the nation's apprentice programs. It is late, time is critically short. The Congress can pull this crucial program out of the mothballs and turn this valuable concept into a useful system for upgrading the national workforce. The JTPA recognizes that realistic training can best be accomplished by private sector employers, on the job. Apprentice training programs provide that kind of training.

There are approximately 300,000 apprentices enrolled in federal and state programs, 20% - 25% are in manufacturing - metal trades. Most of the industrial small businesses are in metal working. Thousands of small metal fabricators provide parts to the robotic assembly lines and automotive manufacturers. According to published articles - Flexible Manufacturing Systems (FMS) increases machine tool utilization by as much as 45 percent with a reduction in workers of 37 percent. Computer Assisted Manufacturing (CAM) has improved electronics production by a factor of 10, or more; and, when combined with Computer Assisted Design (CADCAM), productivity increases as high as 15:1 have been achieved. Most of the others are in the building and construction trades. I will assert unequivocally, the apprentice programs have been overtaken by new technologies. Metal working trades are most impacted by the new production technologies. Unemployment in this sector is probably the highest of any sector. While advances in manufacturing technologies and displacements of hundreds of thousands of auto workers and others are well publicised, there is no plan to identify and publicise obsolete occupations, or to discontinue these apprenticeships, or, to establish apprenticeships in the new technologies. Why is this? For one reason - among many others - the Fitzgerald National Apprentice Act and subsequent policies have produced interpretations that only those occupations listed in the DOT can be apprenticed. Further, administration of these programs is encumbered by divisions of authority between federal and state apprentice councils and statutory provisions requiring employment and wages to be in consonance with collective bargaining agreements negotiated by the unions. Surely, this vital program deserves more current and realistic legislative guidance and support. I submit this is a major area for oversight investigations and remedial legislation.

- PART III - DEPARTMENT OF COMMERCE -

The preceding testimony has dealt with situations in the Departments of Education and Labor. And, while I am inclined to discuss similarities in the U.S. Civil Service, I will conclude this testimony with comment on the employment and unemployment statistics used by the Congress in assessing national employment, unemployment, and associated legislation.

The Congress must recognize that employment and unemployment statistics are of questionable validity. In fact, the extent of errors is potentially so extensive the Congress should have serious reservations about passage of any legislation deriving from Bureau of Labor (BLS) statistics. One might argue that even inaccurate statistics might be useful in indicating trends - since such invalid statistics have been in use for years. I feel the Congress will not accept that argument. Further, if the Congress takes into consideration the absence of any system to create new occupations, and to identify the obsolescence of thousands of present occupations listed in the DOT, VEDS, Occupational Outlook Handbook, and Department of Commerce data (as described in the following), it will probably agree with the remark of some of the Joint Economic Committee staff following my briefing for them - "Garbage in; garbage out." Can the nation afford to expend billions of dollars for new jobs programs on the basis of such "garbage"?

It is well known among occupational authorities of the three departments that the BLS cannot establish a valid "cross-walk" between the occupations used by the Department of Commerce Current Population Survey (CPS) data, and occupations in the DOT. Nevertheless, CPS statistics are a major factor in BLS employment and unemployment statistics reported to the Congress. Further, the CPS statistics are used by the DOL to forecast employment for jobs listed in the Occupational Outlook Handbook.

The Department of Commerce Demographic Survey Division, Current Population Survey Branch, is responsible for the conduct of monthly surveys of approximately 58,000 households located in 629 Population Survey units. These are geographical units determined on the basis of population densities. Approximately 60% of these surveys are made by telephone calls, 40% by direct visits - usually in first contacts with a household. The surveys are conducted on the basis of a printed questionnaire. In a previous study of that questionnaire, it appeared to me that much of the information required in completing the form is ambiguous and introduces an undetermined error rate. Further, the accuracy of response information is affected by the education and experience of respondents, including their understanding of the occupations for which employment or unemployment information is elicited. Some of the Department surveyors advised they were not fully familiar with the occupations on which information was obtained. For some years, the CPS Branch has used "400 groupings of occupational titles" (without definitions). This has been changed recently in attempts to correlate response information with Department of Commerce Standard Occupational Codes (SOC). Persons who worked on these codes advise that the codes do not serve to validate the occupations to which the codes relate. It seems this system is somewhat analogous to the NOICC. There is a difference. The SOC does promote identifying and relating occupations to the standard industry classifications (SIC). The staffs recognized the impossibility of establishing a "cross-walk" between the "400 occupational groupings" and the DOT. And, as noted previously, Department of Education staffs admit to difficulties in establishing a "cross-walk" between their VEDS codes and the DOT. These difficulties are further compounded in BLS statistics by the inclusion of employment and unemployment statistics from various industries and unemployment compensation statistics. To what occupations do these statistics relate? I am confident this Committee and The Congress can see the need for investigations in these conflicting data systems. And, I might suggest that the Congress express reservations henceforth in passing new legislation dependent upon these statistics.

What will the Congress do? The Congress should address itself to the greatest task ever confronting any nation's legislative body - to design and engineer a new national workforce. The magnitude and complexity of such undertaking will challenge the entire Congress. But, as the chairman of one of the nation's major corporations noted in an address at Notre Dame, "What is at stake is a way of life we have taken for granted in this century." Another official in one of our major automobile manufacturing corporations advised me - "This is one competition we must win; we may not have another opportunity in this century, or the next." The architectual elements for a new national workforce are indicated in this testimony. Will the Congress be the architect of our new workforce?

Thank you for this opportunity to testify before this Committee on Small Business, Subcommittee on Oversight and The Economy.

W. Clyde Helms, Jr.
President
Occupational Forecasting, Inc.

HOUSE COMMITTEE ON SMALL BUSINESS
SUBCOMMITTEE ON OVERSIGHT AND THE ECONOMY
MAY 17-18, 1983
MR. HELMS -- EXHIBIT 1

A STRUCTURE FOR ASSESSING OCCUPATIONAL CLASSIFICATIONS AND FORECASTING NEW NATIONAL WORKFORCE OCCUPATIONS (C)

The purpose of this structure is to provide employers, employees, educators, and students, and others responsible for maintaining a current and effective national workforce this terminology for assessing the status of the workforce, and, identifying and acting upon evidence of **obsolete and obsolescent occupations, and new, emerging, and emergent occupations**; to take such steps as are indicated in promoting national and individual interests. There is no system such as this in operation within the United States, or any other industrial nation. It is believed establishment of such system and publication of information derived through the following assessment and forecasting classifications will be of nationally significant value in advancing the interests of the people and the nation.

. . . .

Obsolete Occupations. Those for which there is no present or foreseeable direct economic value when compared with employers' and employees' sustaining income requirements; and, in which levels of employment have decreased to a minimum percent of previous employment, over a reasonable statistical period of time. Such occupations may be discerned at an early state in minimal growth demand - compared with all other occupations - and diminution of wages and salaries. Other indications will be noted in the workplace and job security of employees.

Obsolescent Occupations. Those for which conditions described under **Obsolete** can be forecast within a reasonable statistical time - for example, 5 years minimum. Such occupations may first be discerned in occupations characterized by **slower growth** (numbers employed and/or compensation levels) **compared to the average growth of all occupations.** A significant indicator may be noted in related education and training requirements, changes in appropriate sciences, technologies, and arts. Assessment and evaluation of these conditions and other impacts will enable the analyst to identify obsolescent occupations.

Current Occupations. Those for which there is a strong present and foreseeable requirement, with associated economic benefits for employers and employees. Such occupations generally reflect **averge or faster than average growth compared to all occupations.** Some of these occupations may not be in the paths of advancing technologies, sciences, and arts - demand may be based upon conditions not affected by or minimally affected by such new developments, or, the need for such occupations may be tangentially improved by such changes. Economic and other conditions support reasonable longevity of these occupations.

Emerging Occupations. Those for which new employment opportunities are well evidenced in the changing patterns of business, commerce, industry, science, technology, and appropriate arts. **Such occupations generally do not have a well defined occupational title, or qualification and employment classification and wage standards.** These appear rather amorphous, but, **sufficient employment is occurring to identify this occupational area.** The numbers of workers employed in this emerging occupational area are likely to be growing at a rate substantially above the average of all occupations; new educational and training programs are being established and **demand exceeds supply, shortages are clearly evident.**

Emergent Occupations. Those for which **early trends in research and development, and the establishment of new industries, businesses, commerce, and other income producing activities evidence needs** which require substantive qualification and lead time preparation by educational institutions, employers, and workers. Impacts upon the workforce evidence needs for substantially **different work skills and educational qualifications. Employment, placement, and wage and salaries standards have to be revised or developed anew.** Evidence of present and future requirements for these emergent occupations first appear - for example - in research and development projects, formation of new - or, substantive changes in existing - industries, businesses, and commerce and other major areas of employment affected by the need for such occupations in meeting predictable employment requirements.

CONCLUSION

Note 1. In the absence of any officially recognized system for assessing the currency of occupations comprising the nation's occupational infrastructure, these definitions have been designed by the author and will be furnished to contemporaries for comment and publication.

To the extent possible, the author will correspond with organizations concerning suggested changes.

In the final development, it is the play of the market place that will produce such definitions and use these in promoting and maintaining up to date national occupational infrastructures.

Note 2. In the interests of promoting discussion, analyses, and development of nationally acceptable terminology, requests for permission to quote from and to reprint this material will be considered.

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House Committee on Small Business
Subcommittee on Oversight and the Economy
May 17-18, 1983
Mr. Helms - Exhibit 2

Excerpts From OFI
Occupations DB-I

Copyright - Occupational[1]
Forecasting, Inc. June 1981

NEW OCCUPATIONS FORECAST

Technological Occupations Forecast	Forecast Estimates - 1990 Job Demand Forecast[2]	Salaries[3] Starting	Mid-Range
1. **Hazardous Waste Management Technician**	300,000	$15,000	$28,000
2. **Industrial Laser Process Technician**	360,000	$15,000	$25,000
3. **Industrial Robot Production Technician**	400,000	$15,000	$24,000
4. **Materials Utilization Technician**	210,000	$15,000	$24,000
5. **Genetic Engineering Technician**	200,000	$20,000	$29,000

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[1] Copyright waived for The Congress.

6. Holographic Inspection Specialist	160,000	$20,000	$28,000
7. Bionic-Electronic Technician	120,000	$21,000	$32,000
8. Battery Technicians (Fuel Cells)	250,000	$12,000	$18,000
9. Energy Conservation Technician	310,000	$13,000	$26,000
10. Housing Rehabilitation Technician	500,000	$14,000	$24,000
11. Emergency Medical Technician	400,000	$16,000	$26,000
12. Geriatric Social Technician	610,000	$15,000	$22,000

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1. Based on Implementation by Mid-1980s.
2. 1982 Dollars.

Excerpts From OFI
Occupations DB-III

Copyright - Occupational
Forecasting, Inc., August 1982

NEW OCCUPATIONS FORECASTS

Computer Interface Occupations-Operators	Forecast Estimates - 1990		
	Job Demand Forecast	Salaries	
		Starting	Mid-Range
A. Technical-Industrial			
1. **Computer Graphics Technician:** Terminal Operator (All Divisions of Graphics, Composition, Illustration, Art)	150,000	$20,000	$35,000
2. **Computer Drafting Technician:** Terminal Operator (CAD-CAM) All Areas of Design and Drafting (Technologies, Businesses, Sciences)	300,000	$18,000	$30,000
3. **Computer Modelling and Simulation Technician:** Computer Assisted Design Terminal Operator - Design, Testing, Evaluation	300,000	$25,000	$40,000
4. **Computer Assisted Manufacturing (CAM) Technician** Factory Onsite Monitor/Controller - Robots, FMC, FMS	120,000	$30,000	$40,000

B. Office-Business/Commerce			
1. **Computer Terminal Information Processor**: Text, Data, Graphics - Applications in Offices, Industries, Institutions	270,000	$20,000	$30,000
2. **Computer Terminal Distributive Information Processor**: Electronic Mail, Electronic Funds Transfer, Information File and Retrieval, Telecommunications, Teleconferencing	140,000	$20,000	$35,000
C. Technical-Industrial			
5. **CAG Terminal Input Artist**	150,000	$18,000	$25,000
6. **Computer Modelling and Simulation Technician**	300,000	$25,000	$30,000
7. **CAD Terminal Product Engineer**	450,000	$14,500	$27,000
8. **CAD Terminal Parts Cataloger**	125,000	$11,000	$17,500

Excerpts From OFI

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Forecasting, Inc. August 1982

FORECASTS OF NEW OCCUPATIONS NEEDED THROUGH 1990s

New Computer Based Software Occupations	Forecast Estimates - 1990		
	Job Demand	Salaries	
	Forecast	Starting	Mid-Range
Software Writers (All Fields)	**Total: 1,830,000 Jobs**		

Examples:

- **Commerce & Business**
- **Engineering (All)**
- **Physical Science**
- **Social Science**
- **Medicine**
- **Law**

See following breakdown by fields.

Note: "S/W Writers" is a new concept originated by OFI. The concept - as described in OFI literature - treats with the needs for applications and/or object code specialists, many of whom will be employed as artificial intelligence program "authors." (W. Clyde Helms)

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A. Software Writers-Commerce & Businesses

Examples:

1. **S/W Writers** - Business Management & Automated Office Operations	150,000	$25,000	$40,000
2. **S/W Writers** - Marketing: Telemarketing, Wholesale, Retail & Supporting Information Bases	200,000	$25,000	$40,000
3. **S/W Writers** - Financial Management: EFT, Electronic Mail, Teletext, Banking, Securities, Real Estate, Insurance	160,000	$30,000	$50,000
4. **S/W Writers** - Publications: Computer Assisted Information, Retrieval, Composition, Printing. Electric Recording, Viewing, Teletext, Cable TV, Cassettes, Optical Discs.	300,000	$25,000	$40

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B. Software Writers-Manufacturing Production

Examples:

1. **S/W Writers** - Production Facility Design; Production Systems Layout (CAD-Computer Assisted Design)	180,000	$35,000	$75,000
2. **S/W Writers** - Computer Assisted Manufacturing Operations (CAM), e.g., Foundry castings, moldings, forming: Machining, Assembling, Testing, Inspection. Flexible Manufacturing Systems (FMS) & Flexible Manufacturing Complexes (FMC)	200,000	$30,000	$50,000
3. **S/W Writers** - Industrial Management (CAM/CAD): Inventory Management & Automated Operations; Receiving, Storing; Transport to Manufacture or Process & Shipment. ("Parts On Demand System" PODS)	120,000	$25,000	$40,000

OFI Data Base Listing terminated here.
These furnished to The Congress as examples.

Mr. BEDELL. Thank you very much, Mr. Helms.

The noncompatability of data from the Department of Commerce current population survey and its occupations in the Directory of Occupational Titles is not new, is it?

Is it your view that the rapid economic changes rendered this noncompatibility more significant today than it has in the past?

Mr. HELMS. I would say today that given the conditions my contemporaries here have described the urgency of our needs for current reliable data has never been more severe. We have the most urgent need in the history of our country for current valid data.

Mr. BEDELL. So you do think it is more significant today?

Mr. HELMS. I certainly do, sir. Mr. Gordon testified here a few minutes ago that if we don't move forward—and forgive me for paraphrasing his remarks here—with new technologies, then we will lose our economic viability, our competitive edge, in international commerce.

Mr. BEDELL. You project 400,000 industrial robot production technicians in 1990?

Mr. HELMS. Yes, sir.

Mr. BEDELL. What number of robots in use at that time?

Mr. HELMS. I don't see the exact number or units of robots as controlling here because as has been indicated in other testimony, robots are not individualistic, self-operating devices. For example, even the robots we have today include sensors such as radar, infrared and sonar. And, as Mr. Gordon indicated, we now have robots very well advanced in visual systems.

Further out, robots will have computed brains. The intelligence of a robot is in the microprocessor, and so the speed and extensiveness at which we employ robots by whatever definition will be controlled by the speed with which these advances are accomplished.

Mr. BEDELL. Do you expect that to be rapid?

Mr. HELMS. I certainly do, sir.

Mr. BEDELL. We have the Bureau of Labor Statistics coming before us tomorrow.

Mr. HELMS. I understand.

Mr. BEDELL. If I understood your testimony correctly, you are somewhat critical of some of their figures in particular.

Mr. HELMS. They are quite aware of my criticism. Some of the remarks I have made here have been presented in seminars for some of the highest level officials in the Department of Labor, and for a substantial number of officials in the Department of Education.

Mr. BEDELL. If you were sitting as I am, as chairman of this committee, what procedure would you recommend in terms of trying to investigate their method of gathering these figures and their projections that they have?

Mr. HELMS. There are Presidential Commission reports, and a National Academy of Sciences report that document and support conclusively the statements and the criticisms I have made here.

Mr. BEDELL. Which are?

Mr. HELMS. The National Academy of Sciences report is "Work, Jobs, and Occupations."

Mr. BEDELL. No, no; your statements of criticism.

Mr. HELMS. Of criticism?

Mr. **Bedell**. I understand your criticism of the Dictionary, that it hasn't been updated.

Mr. **Bedell**. But in the Bureau of Labor Standards reports that I see, they say there will be so many people engaged in operating filling stations and so many people engaged as janitors and so many people as secretaries and so on, and this is what they would project into the future. Do you have criticism of that?

Mr. **Helms**. Yes, sir!

Mr. **Bedell**. Do the reports you talk about question those statistics and how those are gathered?

Mr. **Helms**. To the extent the BLS statistics furnished to the Congress on occupations, employment, and unemployment are affected by statistics compiled by the Department of Commerce Current Population Survey Unit—that information is not reliable.

The National Commission on Employment and Unemployment Statistics published a report similar to that published recently by the National Academy of Sciences.

Mr. **Bedell**. I would appreciate it if you would get it for the staff. It would be good if we could have it before the Bureau of Labor Statistics.

Mr. **Helms**. I will call you this afternoon.

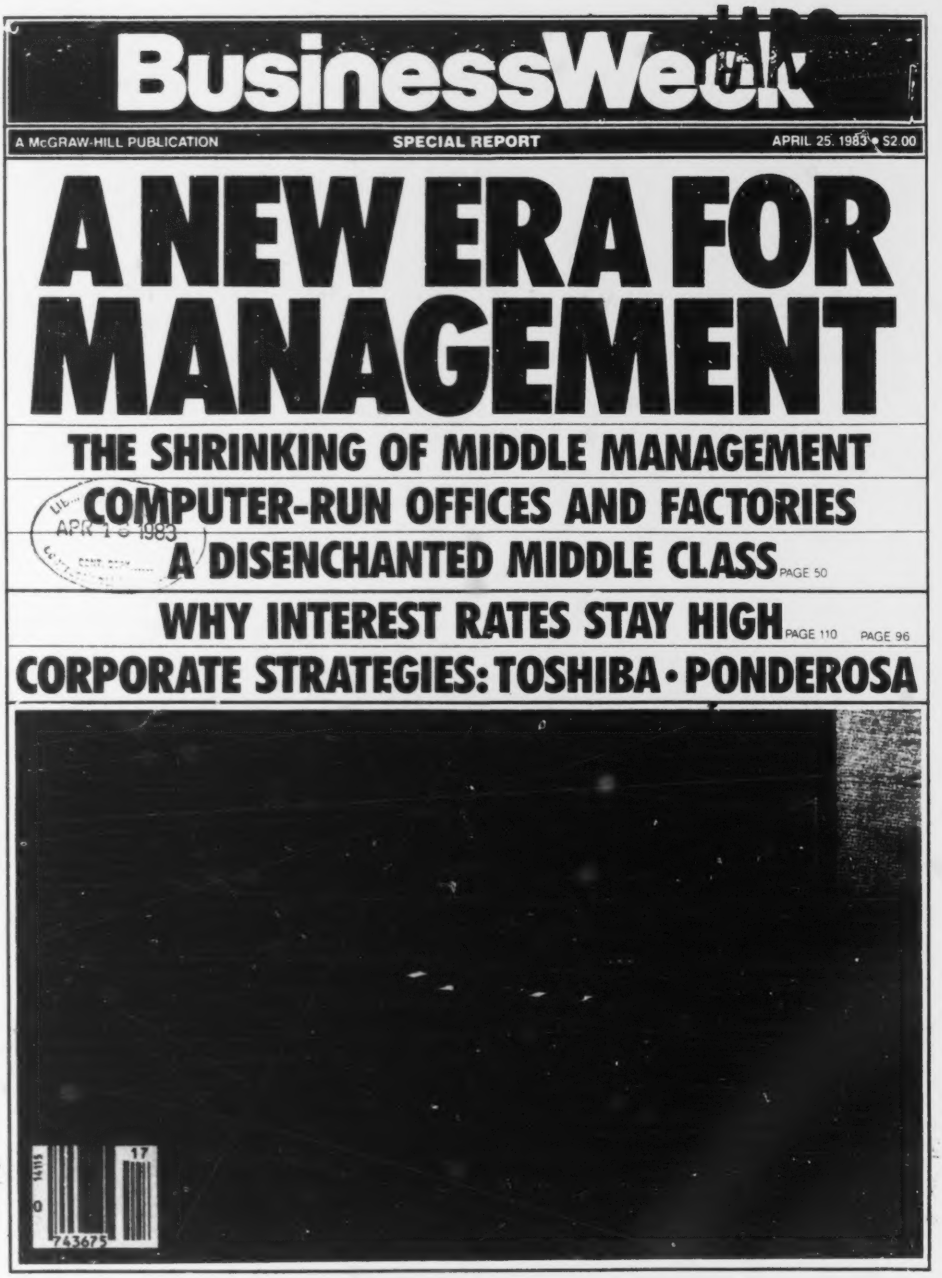
Mr. **Bedell**. You indicated also that you thought there was going to be significant reduction in white collar personnel and middle management people.

Mr. **Helms**. Right.

Mr. **Bedell**. In Japan they do have significantly fewer layers of management than we have for similar things, and I therefore would think there would be some legitimacy to your statement in view of the need for us to become competitive with Japan. Every white collar worker increases your cost to some extent. So do you have any documentation of that, because one of the projections I think by the Bureau of Labor Statistics would be that we will see an increase in the number of white collar jobs as well?

Mr. **Helms**. The Business Week of April 25, cover story is titled: "A New Era for Management." It identifies major corporations in this country who are already eliminating middle management. The reason for this compression is that in the automated offices, the information presently generated at operating levels, and passed to middle management officials, is now available in the automated equipment and computers directly to top management and chief executive officers. So we can leapfrog over middle management. I commend this issue to the attention of this committee.

[The article referred to above follows:]



BusinessWeek

A McGRAW-HILL PUBLICATION   SPECIAL REPORT   APRIL 25, 1983 • $2.00

A NEW ERA FOR MANAGEMENT

THE SHRINKING OF MIDDLE MANAGEMENT

COMPUTER-RUN OFFICES AND FACTORIES

A DISENCHANTED MIDDLE CLASS PAGE 50

WHY INTEREST RATES STAY HIGH PAGE 110

PAGE 96 CORPORATE STRATEGIES: TOSHIBA • PONDEROSA

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Special Report

A NEW ERA FOR MANAGEMENT

As companies grew rapidly after World War II, middle management—whose function was to turn the policy decisions of top management into the dollars and cents of revenues—grew even faster. And their function changed. More and more, they became collectors of information, which they then analyzed, interpreted, and passed on to top executives. The staff middle manager did not run anything: He was merely supposed to advise others on strategic planning, marketing, engineering, and manufacturing. But from that position he gradually came to dominate the line operations that produced and sold the goods and services that brought in the company's dollars.

Suddenly, that is being turned upside down. The onrushing electronics revolution is changing the role of the middle manager and forcing a radical restructuring of the corporation's middle ranks, shrinking them drastically in the best-managed companies. Just as the industrial revolution changed hierarchies, radicalized labor, realigned political forces, and created widespread social and psychological disruption, the technological revolution is producing pain and strain. The initial impact is being felt by the middle manager, who typically earns $25,000 to $80,000. And, as in the earlier upheaval, the woes overshadow even the most glowing promises of the future.

'REDUNDANT.' Ironically, many of those in the first skirmishes have not yet perceived the magnitude of the revolution. It started with modest modernization of bookkeeping chores—the purchase of computers for data processing—and quickly gathered steam. Now it is being fueled by hard times. As more top managers see that much of the information once gathered by middle managers can be obtained faster, less expensively, and more thoroughly by computers, they have begun to view many middle managers as "redundant." They look on the very fiefdoms they have created as vast cost centers, contributing little to profits and much to overhead. Where once they eagerly added to staff as symbols of their power, today they enviously eye Japanese competitors who all along realized that less meant more.

The shrinking of middle management
PAGE 54

Computerizing offices and factories
PAGE 68

Who will retrain the obsolete managers
PAGE 76

The disenchantment of the middle class
PAGE 82

That attitude is showing up in employment patterns. Eugene E. Jennings, a professor at Michigan State University, estimates that one-third of the 100 largest U.S. industrial companies are paring management, and there are clear signs that others will follow. The Bureau of Labor Statistics places unemployment among managers and administrators in nonfarm industries at its highest levels since World War II. And that does not include the thousands of managers who accepted early retirement or opened their own businesses.

To be sure, the severe recession has contributed to cutbacks. But relatively slow economic growth is likely to be a fact of life throughout the 1980s: The average annual rate for the decade will be only 2.3%, according to Data Resources Inc. Competition from abroad is increasing, too. And executives are realizing that only the leanest, fittest companies will survive through the rest of the century.

Economic necessity and technological forces are thus combining to keep a permanent crunch on middle managers. And some of the broad implications of that are beginning to emerge:

☐ Corporate structure is changing to accommodate broader information gathering and to let data flow from shop floor to executive suite without the editing, monitoring, and second-guessing that has been the middle manager's function.

☐ Middle managers who survive find their roles expanded and their functions changed. Generalists, not specialists, are needed, as companies demand solutions to interdisciplinary problems.

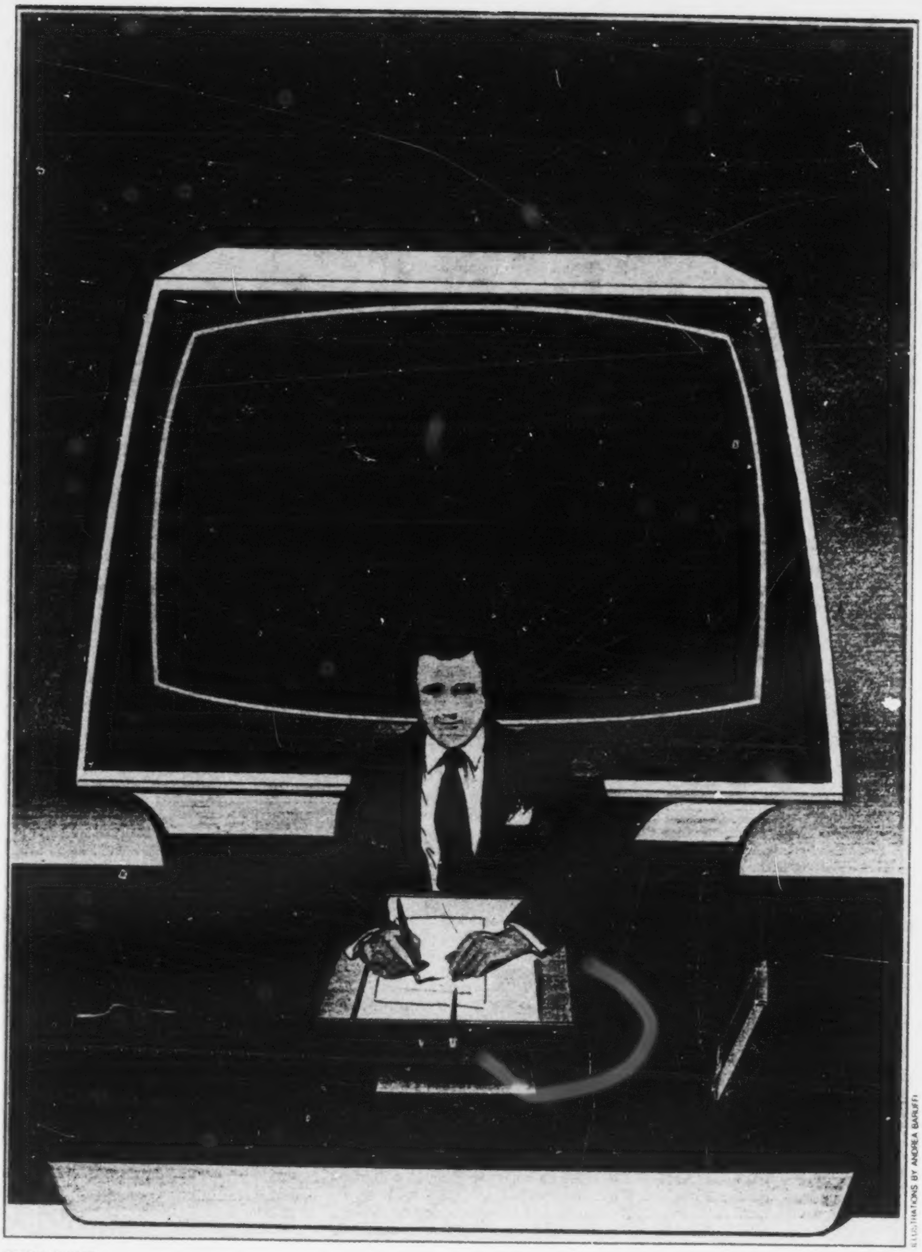
☐ Fewer business-school graduates are hired; those who are find the ladder harder to climb. As corporate pyramids are flattened, with fewer levels, there are more lateral moves and lowered expectations.

☐ Marketplace and manufacturing decisions are made by first-line managers, whose power had been eroded by staff. Foremen now serve in pivotal roles, managing better-educated, more demanding workers and knitting maintenance, engineering, and personnel managers into integrated operating teams.

☐ Business education will focus less on analysis, financial maneuvers, and gamesmanship and more on teaching manufacturing, marketing, and computer skills. For the next generation, retraining will become as important as initial training.

☐ Displaced managers will need safety nets as their health and pension benefits are lost. Many will find it impossible to maintain their standards of living. Higher drug and alcohol abuse and family problems are reflecting the psychological devastation of this group.

☐ Middle managers, who have traditionally been politically conservative, may



ILLUSTRATIONS BY ANDREA BARUFFI

become radicalized under pressure, demanding welfare benefits they once only grudgingly conceded to the poor.

It is becoming clear that the restructuring is essential if companies are to survive in the tougher environment. Yet the hard choices for top managers are equally clear. No matter the cost, they must be able to react quickly to change, push their companies to be more productive, and upgrade their products as rapidly as technology dictates.

Recognizing this, experts are beginning to see that organizations and cultures must be overhauled and even rebuilt. Indeed, helping companies accomplish this appears to be replacing strategic planning as the new growth business of such big consultants as McKinsey & Co. and Booz, Allen & Hamilton Inc. "Implementation—making a strategy happen—is increasingly what consulting is all about," says John M. Harris, a Booz-Allen senior vice-president. "Companies have had to rethink a lot of the things they've done over the last 20 to 30 years in adding staff, middle management, and analytical jobs," says Daniel M. Glasner of Hay Management Consultants. "What they're saying is, 'We used to do without these things. The recession is forcing us to do without them. And we'll continue to do without them in the future.'"

THE NEW HEROES. That view is pervading executive suites. Declares Rene C. McPherson, retired chairman of Dana Corp.: "The fat is not going to come back." Even with an economic upturn, increased competition means every penny counts. So cuts in middle-management staffs of old-line companies, ranging, for example, from 20% at Firestone and Crown Zellerbach to 40% at Chrysler, are not likely to be reversed. Indeed, they might deepen.

Even industries anticipating steady, albeit slower, growth have slashed staff. Texaco, Exxon, and Mobil have cut planning and marketing staffs, while Alcoa, with demand growth averaging 3% per year—down from 8% in the 1960s and early 1970s—trimmed total management by about 15%. Mergers have resulted in still more reductions. Allied's alliance with Bendix and Occidental Petroleum's with Cities Service, for example, have or probably will make scores of middle managers superfluous.

Those who remain find little security. Instead of serving as monitors of operations, staff managers are now servants of the divisions they ruled, and they must justify their existence. The new corporate heroes actually make, sell, or service products, and are rewarded on how well those jobs are done.

"The 1980s will be a decade in which manufacturing and line operations will be stressed much more than in the last 20 years," notes Robert S. Kaplan, dean of Carnegie-Mellon University's Graduate School of Industrial Administration. Adds Jack F. Reichert, president of Brunswick Corp.: "We've been rewarding bookkeepers as if they created wealth. U.S. business has to make more beans rather than count them several times."

At some companies these sentiments have been put into action. General Electric Co.'s new chairman is John F. Welch Jr., an engineer who built the company's plastics business. Picked by his predecessor, Reginald Jones, a financial expert who had made a careful study of the technological needs of the future, Welch was chosen because he demonstrated entrepreneurial and technical abilities. General Motors Corp.'s president, F. James McDonald, is using his engineering and managerial skills in an effort to improve car quality.

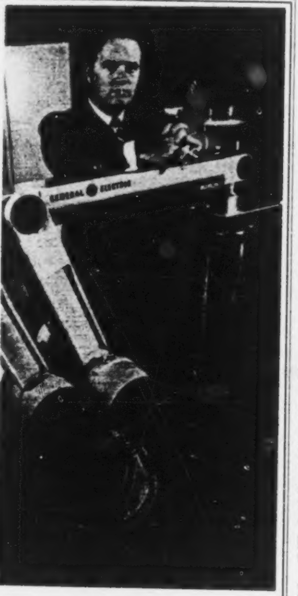
These leaders share a common background and value system: They all have operating experience, and they have succeeded in the new environment, assimilating new technology into products and forging blue- and white-collar workers into teams. They respect accomplishment and promote accordingly. Typical is James A. Meehan's rise at GE (box).

If Meehan is the new corporate hero, less accomplished managers are viewed as enemies. Within weeks of assuming control of Honeywell's computer operation, Vice-Chairman James J. Renier lopped off 1,371 staff and other middle managers. Says Renier: "There are two ways of managing: One requires a lot of useless staff, and the other lets people do their jobs and tell you what expertise they need. If you've got a staff that is either trying to do the line job or has turned into a large group of scorekeepers, you had better get rid of that staff."

"People who make decisions, not recommendations," are the only middle managers currently in demand, reports J. Gerald Simmons, president of Handy Associates Inc., a New York-based executive recruiter. Even McKinsey, one of the management consultants famous for hiring MBAs, is shifting its recruiting focus from business schools to industry.

FREEDOM TO ERR. But cultures are hard to change. In its battle to become more competitive, Xerox Corp. has had to fight its entrenched system. Managers are still reluctant to use their newfound authority for fear of being second-guessed. Executive Vice-President William F. Glavin recalls a line vice-president vacillating over a pricing move because it differed from the view of the staff man who once made such decisions. "The corporate culture change is huge," Glavin acknowledges.

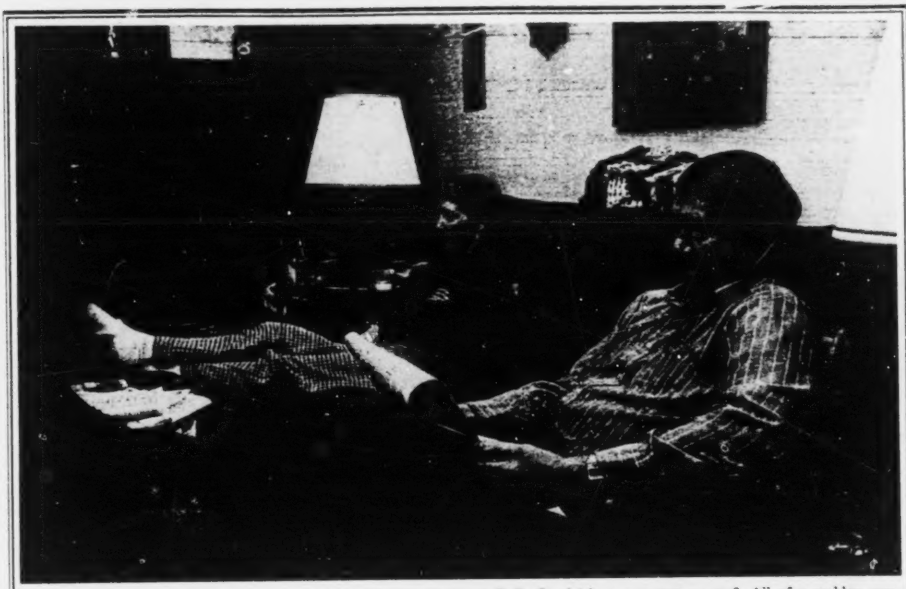
So even when GE's Welch warns his managers that there is room only for the "better than the best," that does not guarantee instant compliance. Freedom to make decisions brings with it freedom to make mistakes, and middle managers want to see what the penalties are before they embrace the new autonomy. Asked to take new risks, they fear reprisals if their performance falls off. Even managers whose specialties are in



PENNY ANN DOLIN

'YOU GET A SENSE THAT YOU OWN THE BUSINESS'

James A. Meehan, 41, who is leading General Electric Co.'s push into robotics, exemplifies the kind of middle manager that Chairman John F. Welch Jr. wants others to emulate. The engineer helped build GE's European semiconductor business and led a small group that developed a low-cost appliance motor. To an ever-increasing extent, says Meehan, "you get a sense that you own the business. What that means is that you're going to spend a lot less time worrying about whose toes you're going to tread on and much more time worrying about how you're going to move that business forward."



SIMON/GAMMA LIAISON

'ALL OF A SUDDEN YOU DON'T HAVE TO BE ANYWHERE'

You might say I feel rootless, like I'm drifting or floating," says Jack L. Shanafelt, 49, who was, until last September, a $50,000-a-year district sales manager at B. F. Goodrich Co. in Akron. Notes Shanafelt: Eight years ago Goodrich had 18 district managers. Two years ago there were 10. Last June there were six. "It's the first time in my life I haven't been attached to something. For 25 years, you get up at 6. All of a sudden you . . . don't have to be anywhere," he says. He has searched and searched and found nothing remotely comparable to his old job. "If I were to start analyzing all of this, I would wind up in a deep depression."

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strong demand have to worry. Stan B. Osenar, director of data processing at Medical Mutual of Cleveland Inc., somberly notes that "even the computer jock is no longer immune. I am safer than a sales district manager, but both of us live and die by our performance."

To make good decisions today, managers must deal with several issues, including the internationalization of their markets, complex financial transactions, and the impact of technology on their products. Technology is also changing the very nature of and need for middle-management jobs. Sales staff in industries ranging from brokerages to pharmaceuticals are, or soon will be, consulting their computers—rather than their managers—for pricing, inventory, and market information. With less paperwork, sales managers can cover larger territories and get faster feedback on performance and problems. Similarly, computer-aided design and manufacturing allowed Chrysler Corp. to halve its engineering group to 4,000 without sacrificing its product-development programs.

Only one element could reverse such cuts: an information-management staff that would rival in size the middle-management group it replaces. Many companies are determined to avoid that pitfall. GE's Drive Systems Div. uses a single data base for all departments to prevent a rise in "infocrat" empires. "The biggest single thing that will make information technology a monster is if information bureaucracies grow up in each function," says Donald E. Kane, GE's manager for corporate organizational planning.

NOWHERE TO CLIMB. Other problems are not as tractable. Fewer management layers mean fewer chances for promotions. "It used to be if you weren't promoted in two years, you weren't on the fast track. But the rapid promotions are ending. We're looking at two to five years, and we won't [promote] sooner unless it's vitally important," says Gerald G. Carlton, vice-president for human resources at Diamond Shamrock Corp.

But this creates new problems. "We can't afford to have a person between the ages of 28 and 35 spend five years on one job, [but] it's hard in our culture today to get people to move laterally," concedes GE's Kane. Adds Howard V. Knicely, vice-president for human relations at TRW Inc.: "American business must escape the syndrome that everything must go up, including people."

All these trends mean that middle-management jobs are becoming tougher, more competitive, and less secure. "It used to be that there was always another rung in the ladder. For many, there is no longer anywhere to climb," mourns a manager in Ohio who was fired and had to settle for a much lower salary.

The fallout will hurt companies as well. Only a few have established retraining programs. Warns Walter K. Joelson, chief economist at GE: "How to get rid of unwanted workers is the name of the game right now. But 7 to 10 years from now it will be tough to find the people we want to hire." Unless companies and universities face up to this, declares Columbia Business School Dean John C. Burton, "we will be writing off a whole generation." One thing is certain: Revolutions never retreat. They may collapse, but considering the impetus behind the electronics revolution, these early changes may represent only the first tremors of an earthquake.

Mr. **Helms** [continuing]. I chaired a discussion panel in the World Future Society Fourth Assembly about a year ago. The discussion panel included such authorities as the provost of Carnegie-Mellon University, the director of Advanced Systems Research Laboratory at Wang Corp., an American Telephone & Telegraph official and others. There was agreement that office automation will have very significant impacts on white collar workers. For example, in office equipment such as the word processor, which is projected to grow at the rate of about 35 to 40 percent or more per year, we have an operator for which we don't have an appropriate occupational title. This operator for example—now titled secretary—interfaces with a computer and processes all of the information that goes into the word processor and is stored on floppy discs.

We can store up to 150 or more letters or pieces of correspondence on a floppy disc. That is going to eliminate thousands of file cabinets and the jobs of messengers and mail clerks, and people like that. These lower level employees are being displaced as well as the middle-management executives by office automation.

We have teleconferencing. We have Telecheck. We have electronic mail. These electronic systems will eliminate many tens of thousands of white collar jobs.

Mr. **Bedell**. I don't know this, but I think the Bureau of Labor Statistics would probably testify their survey would indicate that even though this is claimed, that their survey indicates that this is not yet happening. Therefore, I think as they project things, they would not expect it to change particularly in the future. If that is their statement and if you feel the way you do, would you believe the problem is that it is happening and they are not detecting it, or would you believe that it is something that you think is going to happen in the future, but has not yet started to happen and the projection, therefore, based on the past is inaccurate?

Mr. **Helms**. I certainly reject any statistics or any conclusion based on statistics developed over the past decade because what is happening today is without precedent.

This is a technological revolution, and that is a calm term for the dramatic, dynamic change sweeping the country and all of our occupations. My disagreement with the BLS has been published in national journals.

Mr. Rosenthal and I have disagreed in print in the publication Changing Times, for example, and various other publications. And, when we look at the past—as the economist Toynbee I quoted here advised—the solutions that worked in the past won't work today. The statistics of decades past are a very poor basis for extrapolating and forecasting the events throughout the rest of this century.

Mr. **Bedell**. So your complaint is not nearly so much how they gather their data or what their data shows as the fact that in your opinion, past data——

Mr. **Helms**. Is untimely.

Mr. **Bedell**. It is not very accurate in forecasting what we can expect in the future.

Mr. **Helms**. Yes, sir.

Mr. **Bedell**. You have no great argument with the way they collect their data and what their data shows?

Mr. **Helms**. I disagree with the way they collect their data, too, sir. I disagree on both points.

Mr. **Bedell**. What is your disagreement with the way they collect data?

Mr. **Helms**. Well, as I've testified the current population survey data and the dictionary of occupational titles have been studied by Presidential commissions and others over a period of decades. They have found these data to be inaccurate, unreliable. Yet the current population survey data is factored into BLS statistics along with occupational employment service statistics, OES statistics. Now, I don't know to what extent these two different occupational systems and statistics influence how they factor this but when I briefed some of the members of the Joint Economic Committee their conclusion was "Garbage in and garbage out."

I do have a flow diagram of these documents and processes. This was developed while working with a Senator here on the Hill some time ago. I would be glad to provide that to this committee if you should like to see it.

I tried to flow the information from the current population survey unit into the BLS or the Dictionary, or the Occupational Outlook Handbook. Given the fact that there is a history of criticism, by Presidential commissions, I think we have definite bases for questioning, to say the least, if not rejecting, the occupational employment statistics being produced by the Bureau of Labor Statistics today. I think there should be a thorough investigation and I am surprised the Congress has not looked into this in the past.

Mr. **Bedell**. But I am still not clear how you would go about such an investigation?

Mr. **Helms**. Well, as I mentioned, working in collaboration with a Senator here in a previous administration, I looked at the survey questionnaires used by the pollsters in the Bureau of the Census. These are difficult to interpret.

The CPU pollsters contacted about 58,000 households located in 628 population survey units throughout the country, dispersed geographically based on population densities.

Most of the data is collected by telephone inquiries. They call the household and ask questions of whomever happens to be home, whether it is someone who really knows what dad is doing, whether he is an automobile mechanic, or whether he is down running the car wash or whatever. Neither the census pollster or the respondent are sufficiently familiar with occupations or jobs. I recommend the committee evaluate the questionnaire format.

Further, I was advised that many of the pollsters are not trained. They are not familiar with occupations. They cannot differentiate between the answers given by people who are really not conversant with occupations.

Other tenuous conditions are laid into occupations. The occupations to which these statistics are related is the Department of Commerce "200 groupings of occupational titles." Those occupational titles cannot be as in the trade talk "cross-walked" to the Dictionary of Occupational Titles. Neither cross-walked nor correlated with the DOT.

Mr. **Bedell**. How many telephone calls did you say?

Mr. **Helms**. About 60 percent or more of the 58,000 households.

Mr. **Bedell**. Now, they also, if I understood it correctly, contact industries as well?

Mr. **Helms**. That is the Occupational Employment Statistics Survey, OES.

Mr. **Bedell**. That is the one that you think is inaccurate?

Mr. **Helms**. Not as much as the one where we are depending upon the current population survey unit in the Department of Commerce.

Mr. **Bedell**. Is that the 58,000 households?

OK. Is that the one that you question?

Mr. **Helms**. Yes, I question that.

Mr. **Bedell**. Do you mention any other one because I understand there are two of them in the cross-check system?

Mr. **Helms**. Yes. I would like to see how they correlate the OES information collected from industries with precise occupations listed in the Dictionary of Occupational Titles. Industry does not respond with DOT occupations. They may give statistics on how many people are employed or unemployed but do not identify the specific DOT occupation to which this relates. I do not think that can be done with all the OES statistics.

Mr. **Bedell**. Without getting into the complaints about the specifics of methodology in aggregate terms, when the BLS projects that there are going to be *x* number of thousands of people working at a particular kind of job 5 years or 10 years out, do you think that their estimates are overly optimistic or pessimistic?

What is the general thrust of this? I understand your quarrel with individual titles.

Mr. **Helms**. I would say pessimistic about the accuracy of the estimates. First, I reject them! Second, I could, therefore, say they are pessimistic, and the reason I think——

Mr. **Fithian**. You think then there will be more jobs than BLS thinks there will be in 1990?

Mr. **Helms**. Overall, I think there will be more jobs than they estimate. I think they are pessimistic, particularly in the new technologies. One of the problems I believe exists here is that the statisticians are not technologists.

They are not in a position to assess the changes and to forecast the growth of new technologies. The dictionary was last published December 1977. As many have advised me, and I advise you, the new occupations will certainly effect the statistics gathered on old occupations, and the new occupations are not in the dictionary. They have never created new occupations. They don't identify or recognize all the new occupations. In other words, on one hand we have the past, the Dictionary of Occupational Titles; and on the other hand, we have the future of new occupations. They are still looking at the past. How can they forecast employment in the future if they can't identify the occupations of the future?

Mr. **Fithian**. So you would guess that unemployment will actually come down, would be your guess, for the future of automation?

Mr. **Helms**. I apologize for giving you that impression. No. I don't think unemployment is going to come down for some time. I think unemployment is going to go up for a while.

Mr. FITHIAN. Oh, you do?

Mr. HELMS. Yes, sir, because so far we haven't seen the impacts of office automation on the white collar force. As I stated here, when the effects of office automation like Telecheck, teleconference, electronic mail and other office automation impact the white collar work force, you are going to see losses of jobs that may exceed in this century the numbers of jobs lost in industry. Obviously, losses here will be affected by advances in other areas and technologies.

Mr. BEDELL. Do you have any further questions?

Mr. FITHIAN. No, I don't. Thank you.

Mr. BEDELL. I appreciate your testimony very much. We are late. What are your slides?

Mr. HELMS. Well, I could show them to you in about 5 minutes.

Mr. BEDELL. OK, if you go through them real fast.

[A slide presentation by Mr. Helms followed for a brief period of time.]

Mr. BEDELL. We certainly appreciate your testimony very much. Thank you, Mr. Helms. The hearing is now adjourned.

[Whereupon, at 12:27 p.m., the subcommittee adjourned to reconvene subject to call of the Chair.]

IMPACT OF ROBOTS AND COMPUTERS ON THE WORK FORCE OF THE 1980's[1]

WEDNESDAY, MAY 18, 1983

House of Representatives,
Subcommittee on General Oversight
and the Economy,
Committee on Small Business,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:35 a.m., in room 2359-A, Rayburn House Office Building, Hon. Berkley Bedell (chairman of the subcommittee) presiding.

OPENING STATEMENT OF CHAIRMAN BEDELL

Mr. **Bedell**. The committee will come to order.

Yesterday, we heard from robot manufacturers and analysts, some of whom estimated a very gradual impact resulting from automation in the workplace, and some who estimated enormous change.

Today we'll hear from the Bureau of Labor Statistics, and discuss their projections of the future of jobs in America.

We'll hear from a professor at MIT, who has compared the number of jobs available with the number of people wanting jobs.

We'll hear from analysts of the impact of technology on our society.

And we'll hear from both labor and management as to training programs exemplary in the field.

The subcommittee hearings will be concluded today on this subject, but the book will not be closed. These hearings are part of an ongoing project undertaken by this subcommittee to make a careful assessment of the nature of employment ahead, and what the public and private initiatives could be to address what many believe will be chronic unemployment.

Unemployment has reached numbers higher and more sustained than we have witnessed in two generations of American workers. Let us then proceed with our assessment by calling to the stand Ron Kutscher, Assistant Commissioner for Economic Growth and Employment Projections of the Bureau of Labor Statistics.

But before we do, Mr. Kutscher, do you have any statement, Mr. Boehlert?

Mr. **Boehlert**. No statement.

Mr. **Bedell**. Mr. Schaefer, do you?

Mr. **Schaefer**. No, sir.

Mr. BEDELL. OK. We'll welcome you here, Mr. Kutscher. It's been my privilege to talk with Mr. Kutscher over at the Bureau of Labor Statistics, and we appreciate your coming over here to testify.

TESTIMONY OF RONALD E. KUTSCHER, ASSOCIATE COMMISSIONER OF LABOR STATISTICS, U.S. BUREAU OF LABOR; ACCOMPANIED BY NEIL ROSENTHAL, CHIEF, DIVISION OF OCCUPATIONAL OUTLOOK

Mr. KUTSCHER. Thank you, Mr. Chairman. I have with me today Neil Rosenthal, the chief of the Division of Occupational Outlook.

With your permission, I'd like to summarize my formal statement, then submit it in full detail for the record.

Mr. BEDELL. You not only have our permission, you have our accommodation for doing so. It seems we often run out of time, and any summary that you can make will be most helpful.

Mr. KUTSCHER. I would like to start by briefly describing the program at the Bureau of Labor Statistics for developing industry and occupational projections.

This program on a regular 2-year cycle develops 5- to 10-year projections of the U.S. economy, including employment by industry and occupation. Those projections are then updated 2 years later. We've published these results in various formats appealing to different audiences.

For example, technical material is provided for technicians interested in how we do the projections. Documents like the Occupational Outlook Handbook is prepared principally for use by high school and college students, and by their counselors. It gives them our best judgment to what the future ahead holds. Briefly, the program that we have is an integrated system that allows us to look at the size and the age/sex/race composition of the labor force, the various economic trends that we project ahead, and the impact that we expect these trends to have on industry output, and then on employment by industry and occupation.

The projections are developed in an integrated framework, so each of the sequences are linked together, and are compatible with each other.

The system has an accounting framework so that all employment is accounted for, both by industry and by occupation.

Now, that has some advantage in the sense that if we're overestimating in one industry, there's a compensating error someplace else in the system.

Another part of the projections is that we regularly evaluate the projections, and publish the results so that the user can gain some insight into how accurate the projections are. The last set of evaluations showed that our average error for industry employment projections was about 8 percent. The average error for occupational projections was about 14 percent. That, of course, is available to users who want to gain insight into the BLS projections.

Now, let me turn to what we see ahead. The labor force we expect to grow over the next decade, at a decreasing rate of increase. Now, this comes about because the so-called baby boom generation has largely been absorbed into the labor force, and the number of 14- to 24-year-olds will decline in absolute numbers over this decade.

The rate of labor force growth is projected to be about 1.5 percent annually, compared to 2.5 percent annually in the 1970's. By the end of this decade the labor force should be growing at about 1 percent per year.

Now, within this overall slowdown in the rate of increase that not only will we be getting the age change that I mentioned, fewer numbers of young people 16- to 24-year-olds, but we also will be getting fewer workers 55 and older. Now, this comes about not because there are fewer people in this age group, but increasingly people 55 and over are choosing to exercise early retirement options. So the labor force participation rate of workers 55 and over is declining.

Within the sex composition of the work force, we project over the next decade that roughly two out of three net additions to the labor force will be women. In other words, of every three people that enter the labor force, two will be women, and one will be a man.

Lastly, with regard to the labor force, we project that the race composition of the labor force growth will change appreciably over the decade ahead.

The birth rate for blacks and whites have followed a much different pattern. The birth rate for whites was lower, started to decline earlier, and declined at a sharper rate. That means for the next decade those entering the labor force, blacks will represent a higher proportion than they represented in earlier time periods.

We estimate that about 1 out of 4 workers over the remainder of this decade will be black, or roughly double their proportion of the total population.

Turning from the overall look at the labor force, what do we see in terms of employment and in particular the industry composition of employment. Well, if one could describe what's happened in the economy over the last decade, you've had very small increases in what we term the goods producing industries. This encompasses agriculture, mining, construction, and manufacturing. With the exception of agriculture, all of these have had a small amount of growth, but at a much slower rate than the total economy.

The BLS projections, continue this pattern. Albeit, we do see a somewhat faster rate of growth for manufacturing in this decade than we did in the last decade, primarily because, as more emphasis is placed on defense expenditures in this decade, that calls forth more output and employment from the manufacturing sector than consumer services, or some of the other demand categories do. However, manufacturing will still decline in relative terms, because the service producing portion of the economy is projected to increase much faster.

When we look at the constituent parts of the service producing industry, we find that transportation and public utilities will grow but be the slowest growing segment of the service producing industry. Wholesale and retail trade generally grows like the total economy. In other words, its share of total employment is roughly stable over time so that if we get about 20 to 25 percent growth in the total economy, we'll have roughly that growth in wholesale and retail trade.

The service category where we look for much faster than average growth, is in a segment we call the other service industry. This encompasses business services, health and professional services. These industries have over the past decade experienced 7 to 9 percent annual growth. Our projections are for these industries to grow at a somewhat diminished rate in the decade ahead, but still to lead the economy in terms of the rate of employment growth.

Significant changes in the composition of the service producing industries toward health services, toward business services, accounting, legal, cleaning, fumigating, all of the things that the business sector requires as we become more office oriented. That has particular implications I'll note later for such jobs as janitors, and occupations such as that.

Finally, the outlook for Government. Government employment, particularly at the State and local level, was, until about the mid-seventies, one of the fastest growing segments of employment in the economy. However, in State and local government employment slowed down appreciably in the late seventies and our projections are that the employment in State and local government will not grow much over the decade ahead.

This comes about from two factors, one of which is that 1 out of every 2 employees of State and local government are involved in some level of education. Of course the age change that I've described earlier means there will be fewer young people in school. Consequently, the growth in education will be less over this decade than it's been in previous periods, although by the end of this decade we will begin to have an upturn at the elementary level, but secondary schools and colleges will still decline in this decade. The second factor affecting State and local employment growth is taxpayer resistance to further tax increases.

Turning from looking at the economy from an industry viewpoint to an occupational viewpoint, we broadly categorize employment into seven different occupational categories. Among those, we find that for the professional and technical category, our growth rate is projected to be about the average for the total economy over this decade.

For managers we look for slightly below average, although it tends to center close to the average. For clerical workers, our projections are for growth above the average growth rate for the total economy. For sales workers we have about average growth, again harking back to the fact that wholesale and retail trade tends to grow like the total economy.

Operatives who tend to be the individuals that operate machines in manufacturing, we project below average growth for this decade. In other words, if technology affects jobs, it tends to be the operative occupational category that's most impacted by changes in technology or automation.

The other category that we have below average growth is nonfarm laborers. Again, the category most susceptible to being impacted by automation is the movement of goods. I'm sure you've heard from the witnesses yesterday that robots can move material, and if jobs are impacted, it's very likely to be the laborers job who picks up material from one place and moves it to another place.

Now, service workers—the people that work in fast food restaurants and beauty shops—this broad category of workers we project to have above average growth. This is the fastest growing occupational category, of course that in some ways is closely related to the above average growth, from an industry viewpoint, for what we call the other service sector.

I'd like to move from this broad look to begin looking at some detail, but first let me describe the job market for college graduates.

One of the things that's happened to college graduates over the last decade is that the college ranks were swelled by the baby boom generation. Consequently, the number of people getting college degrees has increased very rapidly.

Now, while the economy demanded somewhat more individuals with college degrees, the supply of people with college degrees increased much faster than the demand.

As a consequence, our data show that during the decade of the 1970's, approximately 1 in 5 college graduates ended up taking a job that the employer said did not require a college degree to do the work. In fact, nearly 10 percent of college graduates in the 1970's ended up in a clerical job.

Now, our projection for the 1980's shows about the same pattern; namely, up to 1 in 5 college graduates will take a job not requiring a college degree. First of all, we have a reservoir of a large number of people with college degrees working in jobs that do not require college degrees. Many of them would be in a position to compete for new jobs that open up that require college degrees. In addition, for most of this decade we will still be turning out more people with a college degree than the job market demands.

So our estimates are for roughly the same proportion; that is, that 1 in 5 individuals who get a college degree in the 1980's will end up taking a job that doesn't require a college degree. Now, that doesn't translate into unemployment for college level people, although obviously their unemployment rate is higher today than it was a decade ago.

What it means is a movement in the job market; that is, the college graduate takes the job that would normally be taken by someone that has a couple years of college. A person with a couple years of college takes the job that would normally be taken by the high school graduate, and the person at the end of the chain, that is the high school dropout will be the one that's affected by this oversupply of college graduates most sharply—at least from the perspective of being unemployed. Now while categorizing the supply and demand of college graduates as being in oversupply, one needs to quickly emphasize that this varies a great deal by field; that is, by the type of degree you get.

Even with this oversupply, we know today that there are degree fields where there aren't enough people. These shortages are heavily concentrated in such fields as computer sciences, some of the engineering fields, particularly electrical, electronic, and aeronautical. Also such fields as teaching of high school math and science, and college teaching of engineering and computer sciences. Now, if we have shortages in some fields that require a college degree, this means that the oversupply in some other fields is very large indeed, and that is true of most other high school teaching fields other than the ones I just mentioned, most college teaching fields, other than the ones I just mentioned as well as in such fields as anthropology, sociology, psychology, and biology. Many fields like this. There are many more people getting degrees in these fields than the job market is demanding. We see this continuing throughout the remainder of this decade.

Turning from the college market to looking at those areas that we think provide the most job opportunities, in my testimony I provide three tables that categorize the fastest growing occupations by level of education required.

The first table tabulates the fastest growing occupation for which a high school diploma, or less, is adequate preparation. It's led off by food preparation and service workers in fast food restaurants; correction officials and jailers, nurse's aides and orderlies, and so on down the list.

The next table, table 2, categorizes the fastest growing occupations that generally require post-secondary education. Again, this is led off by paralegal personnel, data processing machine mechanics, and computer operators, and so on down that list. These are the occupations that we project have the fastest rate of growth over this decade.

Table 3 lists the fastest growing occupations that usually require a bachelor's degree, or beyond, and this is headed by computer systems analyst, physical therapist, computer programers, speech and hearing clinicians, and so on down the line.

Now, all of these three tables isolate the fastest rate of growth. However, one of the things that is important to note for most of these, although not all, if you look at the employment column from the base for which we show this for 1980, you'll see that many of these occupations employ relatively few in number. If you're talking about an economy with 100-million-plus people employed, an occupation that's employing 30,000 is not accounting for a very large share of total employment.

Therefore, table 4 brings this all into perspective, and that is, in table 4 we categorize employment growth of all occupations. We develop projections at the BLS for about 1,000 different occupations in the economy. However, this list that is tabulated in table 4 accounts for 50 percent of the total projected growth between now and 1990. Most people, when they see the list, are surprised in terms of what occupations are shown is what has been commonly termed high-tech occupations; that is, the technicians required in health services, computer-related occupations are not on this list.

When we look at the total economy, we see that the economy is still run with secretaries, nurse's aides, sales clerks, cashiers, and truckdrivers, that our projection for the decade ahead is that these are the types of jobs that the economy will continue needing in the future even with the types of changes that we're focusing on.

This is emphasized most by saying that the occupations that over the last decade have the fastest rate of growth are some of the computer occupations. I'll list them in the final pages of my testimony as having growth rates that vary from almost 500 percent, down to keypunch operator with only 28 percent growth. However, when you accumulate all of the growth of all the computer-related occupations in the economy over the last decade, they still only account for 5 percent of the total growth in jobs over this period.

So that one of the points I want to make is that in looking at jobs, I think we need both perspective. I'm not saying we shouldn't look at the fastest-growing occupations, but we should keep in mind that many of those that are growing rapidly are growing from a very small employment base. Also look at those occupations that by and large have a large employment base, but have relatively slow growth projected for them.

Finally, the point I'd like to make in closing, is that the jobs listed in table 4, many of those are jobs not likely to be affected by robots and other automation that may be introduced this decade.

Now, that's not to say there are not jobs that will be affected by that. In our analysis we find that jobs of welders, production painters, and material handlers, are very likely to be significantly affected by robots in the decade ahead.

That closes my formal remarks, Mr. Chairman. I'm ready for questions at this time.

[Mr. Kutscher's prepared statement follows:]

PREPARED STATEMENT OF RONALD E. KUTSCHER, ASSOCIATE COMMISSIONER OF LABOR STATISTICS, U.S. BUREAU OF LABOR

Chairman Bedell and Members of the Subcommittee on Oversight and the Economy it is a pleasure to be asked this morning to describe for you the Bureau of Labor Statistics' employment and occupational projections. In my testimony I will review the program of the Bureau of Labor Statistics which provides industry and occupational employment projections. Also, I will discuss the major long-term trends in employment at the industry level and at the occupational level that emerge from the analyses done as a part of the Bureau of Labor Statistics projections program.

One of the programs of the Bureau of Labor Statistics provides projections of the U.S. economy including employment by industry and occupation. These projections typically cover a 10 year ahead horizon and are updated on a regular two year cycle. The projections described here were published in the fall of 1981 and spring of 1982. They will be updated by a new set of projections in the fall of 1983 and spring of 1984. The projections are developed under alternative economic assumptions and the results are presented in varying formats to meet the needs of diverse users. The Occupational Outlook Handbook, designed principally for high school and college students and counselors to these students, is one of the ways the projection results are presented. Other publications are designed to meet the needs of educators and training specialists, the research community, and others interested in employment and occupational trends. Another important element of the projections program in the Bureau is a regular detailed evaluation of each set of projections once we have reached the period covered by the projections.

How the Bureau Prepares Occupational Projections

The Bureau's system for developing occupational projections was designed to take into account, as best as we can, the factors that can influence trends in employment by industry and occupation. Of course, one has to be clear that developing projections of industry and occupational employment is an inaccurate operation because of the wide variety of factors that come into play. The preparation of economic projections uses, to a degree, both science and judgment. Thus, misunderstandings may arise between the users, who feel the need for exact numbers, and producers, who recognize their inability to predict with such precision. The Bureau of Labor Statistics attempts to address this dilemma, in at least a small way, by making clear all the important assumptions underlying our projections, by developing alternative versions which reflect at least some of the uncertainties about the future, by evaluating past projections to assist users in appreciating the unpredictable nature of certain events, and by updating the projections on a regular 2-year cycle.

The projection system used by the Bureau of Labor Statistics can be viewed as several discrete steps or elements which are closely related to each other. First, we develop labor force projections by age, sex, and race. This provides an estimate of the total number of people available for work and their demographic composition. Second, we use an economic model and a specified set of assumptions to develop projections of economic growth and its composition. Composition of GNP encompasses changes in consumer demand for goods or services, changes in trends of Federal and State and local government expenditures, business and residential investment, and changing patterns of exports and imports. Third, these overall aggregate economic projections and the changes in distribution of demand are translated into industry output and employment requirements by using an input-output model. Lastly, employment by industry is translated into occupational employment using an industry occupational matrix, which shows the staffing patterns for each industry in the economy. These steps, when combined, provide projections of occupational employment for a future time period under a specified set of economic assumptions. A detailed description of the methods used by BLS is contained in, "BLS Economic Growth System Used for Projections to 1990," BLS Bulletin 2112, April 1982.

Technological change--an important focus of these hearings--enters the BLS projections system in two explicit ways. The input-output portion of the Bureau's projection system depicts the relationships among industries by showing what they buy and sell each other to produce their industry's goods and services. These input-output relationships can change for a number of reasons including changes in technology. For example, firms within an industry can begin purchasing outside accounting services formerly performed inside the firm or clerical work performed by hand can be done by computer, necessitating the purchasing of a computer, computer parts, software and other inputs needed to operate a computer. Second, the staffing patterns by industry can also change due to many factors including technological change. In the examples noted above, if firms within an industry decided to purchase outside accounting help, not only would a purchase of accounting services show up in the input-output model but a decline of accountants in that industry would also show up in the industry-occupational matrix. Similarly, changes from hand calculation to computer calculation would induce changes in the occupational mix. In developing projections, we attempt to take into account the impact that technology will have at both of these points in the BLS projections process. In this work, studies conducted in the Bureau's Office of Productivity and Technology of technological changes occurring in industries are important. However, even with these studies and other analyses developed, the future impact of technological change is very difficult to forecast both as to its speed, to its dispersion, and to the exact quantification of its impact. Consequently, we would be less than honest if we did not say that a large element of judgment enters into this aspect of our projections. To the extent that we fail to capture future technological change the projections can be in error, just as they can be if our assumptions are incorrect or if we do not correctly gauge a change in consumer preferences or government priorities. Both of these point up the uncertainties attached to developing detailed projections of employment at an industry and occupational level.

While this system develops projections of occupational demand, other related elements such as education and training requirements, and future job prospects in specific occupations depend on additional considerations. Thus, projections of employment by themselves do not indicate what the likely supply-demand situation is going to be in a given occupation. In developing data on supply-demand balances and future job openings, it is very important to emphasize that, on average, nine out of ten job openings in the economy stem from the need to replace workers who leave their occupation rather than from growth. It is also important to emphasize that this overall average varies considerably. For example, in some lower skill occupations, the relationship between openings due to replacements and growth may be 20 - 1, while for other occupations at the high end of the skill spectrum, a much smaller relationship exists. Also, it is important to note that while the Bureau has studied and developed over many years, data and a system for projecting growth in employment, job openings due to occupational mobility is something on which we have only recently begun to develop data and on which, as a consequence, we have far less knowledge.

The Bureau has recently developed a data series that has enabled us to do some in-depth analysis of occupational mobility. One of the important insights gained from these data is that there is significant mobility in the nation's work force even among occupations such as engineers that have considerable training or education requirements. Since mobility depends on a variety of economic factors, it is very difficult to use these data to evaluate future supply. Further complicating assessments of future supply in a given occupation is that the number of individuals in a career-oriented education program do not always enter the occupation in which they are trained. For example, it is estimated that only 80 percent of the graduates of engineering schools eventually become engineers. That may be due to job market factors or it could be due to personal preferences. All of this only serves to point out the uncertain nature of developing highly accurate projections of job openings by detailed occupation and assessment of the supply-demand balances for an occupation five to ten years ahead. For this reason, we present our projections in terms that are carefully worded so as not to give an impression of a precision that is clearly not there.

Major Long-Term Trends

I would like to turn now to a review of the major trends emerging from the Bureau's projection analyses. Before doing so, I would note that, since these projections are developed on a two year cycle, they do not always incorporate the Administration's latest economic forecast. For a description of the assumptions used in these projections, as well as the full detail of the results, see, "Economic Projections to 1990," BLS Bulletin 2121, March 1982. I will begin that review with the labor force. The civilian labor force, consisting of people with jobs—wage and salary workers, self-employed workers, and unpaid family workers--and people looking for jobs--the unemployed, through the late 1960's and the 1970's grew tremendously. This growth resulted because many people born during the "baby boom" entered the job market, and an increasing proportion of women in the population sought jobs. In 1980, the civilian labor force totaled about 105 million persons--63 percent of the noninstitutional population 16 years of age and over.

The labor force is projected to continue to grow during the 1980's but at a slower rate than in recent years. By 1990, the size of the labor force is expected to range from 122 to 128 million persons, a 17 to 22 percent increase over the 1980 level. Contributing to this growth will be the expansion of the working age population and the continued rise in the proportion of women who work. The labor force will grow more slowly between 1985 and 1990 than in the early 1980's. This slowdown will result from a drop in the number of young people attaining working age and on a projected less rapid growth of the participation rate of women.

To discuss employment trends and projections by industries, it is useful to divide the economy into nine industrial sectors under two broad groupings--service-producing industries and goods-producing industries. Over two-thirds of the Nation's workers are currently employed in industries that provide services such as health care, trade, education, communication services, government, transportation, banking, and insurance. Industries that produce goods through farming, construction, mining, and manufacturing employ less than one-third of the country's work force.

Over the last two decades a number of important shifts in employment have taken place in the economy. Perhaps the most publicized among these is the relative shift away from the goods-producing sectors to the service-producing industries. Most of the employment growth over the last two decades has been growth in service-producing industries with little absolute job increase among the goods-producing industries. Within the goods-producing sector agriculture has had employment declines, while the manufacturing sector has declined in relative terms but not in absolute levels--at least not over the long run. Cyclical downturns, of course, have resulted in declines in the number of manufacturing jobs.

SERVICE-PRODUCING INDUSTRIES. Employmant in service-producing industries has been increasing at a faster rate than employment in goods-producing industries in the past and that pattern is projected to continue. Employment in the service-producing industries is projected to increase from 65.7 million workers in 1980 to between 78.7 and 83.5 million in 1990 or by 20 to 27 percent. However, growth will vary among industries within the group. The following paragraphs summarize recent trends and the projections of employment in the five industrial sectors that make up the service-producing industries.

Transportation and Public Utilities. This is the slowest growing sector of the service-producing industries. Between 1970 and 1980, employment in this sector increased only one-third as fast as in the service-producing industries as a whole, due largely to declining employment requirements in the railroad and water transportation industries. However, even in the communications industries where demand has increased greatly, technological innovations have allowed for the expansion in services with a relatively small employment growth. Between 1980 and 1990, employment in the transportation, communications, and public utility sector is expected to rise from 5.5 million to between 6.5 and 7.1 million workers, or by 12 to 22 percent.

Trade. Both wholesale and retail trade employment have increased as the population has grown and as rising incomes have enabled people to buy a greater number and variety of goods. Retail trade grew slightly faster than wholesale trade during the 1970's, 38 percent compared to 32 percent—as expansion of the suburbs has created a demand for more shopping centers. Between 1980 and 1990, wholesale and retail trade employment is expected to grow from 20.6 million to between 25.1 and 26.8 million workers, or by 22 to 31 percent. Employment will continue to increase faster in retail trade than in wholesale trade, 24 to 31 percent compared with 17 to 28 percent.

Finance, Insurance, and Real Estate. This sector grew 42 percent between 1970 and 1980 as these industries expanded to meet the financial and banking demands of a growing population. Between 1980 and 1990, employment in this sector is expected to rise from 5.2 million to between 6.5 and 6.9 million workers, or by 26 to 34 percent. A growing population that increasingly uses credit to finance purchases will keep the consumer demand for credit and other financial services high. In addition, businesses will need assistance to finance the expansion of their plants and the purchase of new equipment.

Other Services. This sector includes a variety of industries, such as hotels, barber shops, automobile repair shops, business services, public and private hospitals, nonprofit organizations, and public and private education. Employment in this sector increased 37 percent between 1970 and 1980. High demand for health care, business services, advertising, and commercial cleaning services has been among the forces behind this growth. From 1980 to 1990, employment in the service industries is expected to increase from 26.2 million to between 31.6 and 33.5 million workers, or by 20 to 28 percent, and will provide more new jobs over this period--5.4 to 7.3 million--than any other industry sector. Employment requirements in health care are expected to grow rapidly due to continued increases in demand because of population growth--particularly the elderly--and rising incomes and increased health insurance coverage that increase people's ability to pay for medical care. Business services, including accounting, data processing, and maintenance, also are expected to grow rapidly.

Government. Increased demand for services provided by the government-- social services and welfare, and police and fire protection--caused employment in the government sector (excluding education and hospital services) to rise about 36 percent between 1970 and 1980. Employment in State and local governments expanded 47 percent compared to 13 percent for the Federal Government. As a result of public desire to limit government growth, employment is expected to rise only 14 to 16 percent in the 1980-90 period.

GOODS-PRODUCING INDUSTRIES. Employment in the goods-producing industries rose only 10 percent between 1970 and 1980. Gains in productivity resulting from automated production, improved machinery, and other technological changes permitted large increases in output without significant change in employment. Between 1980 and 1990, employment in goods-producing industries is expected to increase from 29 million to between 32.5 and 35.5 million workers, or by 13 to 22 percent. Growth rates will vary among the four sectors that make up this group--agriculture, mining, construction, and manufacturing.

Agriculture. Employment in agriculture, which has long been declining, dropped an additional 7 percent between 1970 and 1980, while farm output increased through the use of more and better machinery, fertilizers, feeds, and pesticides. Between 1980 and 1990, employment is projected to continue declining but, in absolute amounts, by less than in earlier periods.

Mining. Having declined through most of the 1960's, employment in the mining sector increased substantially during the 1970's. Employment rose about 65 percent between 1970 and 1980, mostly because of the country's renewed emphasis on developing energy sources. Continued growth of between 20 and 30 percent is projected for the 1980's.

Construction. Despite several economic slumps, employment rose 25 percent between 1970 and 1980, because of strong demand for houses, apartments, office buildings and highways. Between 1980 and 1990 employment in the construction sector is expected to increase from 4.5 million to between 5.6 and 6 million workers or 24 to 34 percent.

Manufacturing. Although a growing population and rising incomes have increased demand for many types of manufactured goods, improved production methods and stiff foreign competition limited employment growth in many manufacturing industries during the 1970's. In fact, employment grew more slowly in manufacturing than in any other sector except agriculture between 1970 and 1980, only 5 percent. Manufacturing employment is expected to rise to between 23.3 and 25.3 million workers by 1990, a 15 to 24 percent increase from the 1980 level of 20.4 million workers. This somewhat more rapid expansion for manufacturing in the 1980's is related to the expected defense build-up and somewhat greater emphasis on investment goods expected in this decade.

Manufacturing is divided into two broad categories, durable goods and nondurable goods. Employment in durable goods manufacturing is expected to increase by about 19 to 30 percent, while employment in nondurable goods manufacturing is expected to increase by only 8 to 25 percent. Growth rates will vary among individual industries within each of these categories. In nondurable goods industries, for example, employment in bakeries is expected to decline, while a moderate rise in employment is projected for the paper industry and strong growth in drug manufacturing. Among durable goods industries, computer equipment manufacturing and medical and dental instrument manufacturing are expected to show rapid rates of employment increase.

Occupational Profile

Customarily, occupations are divided into white-collar occupations--professional and technical, clerical, sales, and managerial jobs; blue-collar occupations--craft, operative, and laborer jobs; service occupations; and farm occupations. Growth rates among these groups have differed markedly. Once a small proportion of the total labor force, white-collar workers now represent about one-half of total employment. The number of service workers also has risen rapidly, while the blue-collar work force has grown only slowly and farm workers have declined. The following section describes projected changes among the broad occupational groups between 1980 and 1990.

Professional and Technical Workers. This category includes many highly trained workers, such as scientists and engineers, medical doctors and health technicians, teachers, computer specialists, pilots, and accountants. Between 1980 and 1990, employment in this group is expected to grow from 16.4 million to between 19.9 and 20.7 million workers or about 20 to 26 percent.

Managers and Administrators. This group includes workers such as bank officers and managers, buyers, credit managers, and self-employed business operators. Between 1980 and 1990, this group is expected to grow from 9.4 million to between 10.6 and 11.3 million, or up 13 to 21 percent.

Changes in business size and organization have resulted in differing trends for self-employed and salaried managers. The number of self-employed business managers will continue to decline as large corporations and chain operations increasingly dominate many areas of business. Some small businesses, such as quick-service groceries and fast-food restaurants, still will provide some opportunities for self-employment. The demand for salaried managers will continue to grow as firms increasingly depend on trained management specialists, particularly in highly technical areas of operation.

Clerical Workers. This constitutes the largest occupational group and includes bank tellers, bookkeepers, secretaries, and typists. Between 1980 and 1990, employment in these occupations is expected to grow from 18.9 million to between 22.4 and 23.9 million workers, or by 19 to 27 percent. Although new developments in computers, office machines, and dictating equipment will enable clerical workers to do more in less time and will change the skills needed in some jobs, continued growth is expected for most clerical occupations. Exceptions include keypunch operators and stenographers which will be affected significantly by new technology. Conversely, however, the more extensive use of computers will greatly increase the employment of computer and peripheral equipment operators. Also, job functions or the manner in which work is carried out will change for secretaries and other clericals as they increasingly use the wide variety of word processing equipment.

Sales Workers. These workers are employed primarily by retail stores, manufacturing and wholesale firms, insurance companies and real estate agencies. Employment of this group is expected to grow from 6.8 million to between 8.1 and 8.8 million workers, or by 19 to 28 percent.

Craft Workers. This group includes a wide variety of highly skilled workers, such as carpenters, tool-and-die makers, instrument makers, machinists, electricians, and automobile mechanics. Between 1980 and 1990, employment of this group is expected to increase from 12.4 million to between 14.6 and 15.8 million, or by about 18 to 27 percent.

Employment in many craft occupations is tied to trends in a particular industry. Employment in nearly all construction crafts, for example, are expected to grow because of rising demand for construction. In contrast, the long-run employment decline in the railroad industry will lessen the demand for some craft occupations concentrated in that industry, such as railroad and car shop repairers. Because of advances in printing technology, very little growth is anticipated in the printing crafts.

Operatives. This group includes such production workers as assemblers, production painters, and welders. Between 1980 and 1990, employment of operatives is expected to rise from 10.7 million to between 12.2 and 13.2 million workers, or by 14 to 23 percent.

Employment of operatives is tied closely to the production of goods, because the majority of these workers are employed in manufacturing industries. The projected slow growth of some manufacturing industries along with improved production processes, including the widely expected increased use of robots, will hold down the demand for many of these workers. Employment of some textile operatives, for example, is expected to decline as more machinery is used in the textile industry.

Transport Operatives. This group includes workers who drive buses, trucks, forklifts, and taxis. Employment in most of these occupations will increase because of the greater use of most types of transportation equipment. Some occupations, such as busdriver and sailor are expected to grow only slowly. Between 1980 and 1990, the number of transport operatives is expected to rise from 3.5 million to between 4.2 and 4.4 million workers or by 18 to 26 percent.

Nonfarm Laborers. This group includes workers such as garbage collectors, construction laborers, and freight and stock handlers. Employment in this group is expected to grow only slowly as machinery increasingly replaces manual labor. Power-driven equipment, such as forklift trucks, cranes and hoists will handle more material in factories, loading docks, and warehouses. Other machines will do excavating, ditch digging, and similar work. Between 1980 and 1990, employment of laborers is expected to increase from 5.9 million to between 6.7 and 7.1 million workers or by 14 to 22 percent.

Service Workers. This group includes a wide range of workers--firefighters, janitors, cosmetologists, and bartenders are a few examples. These workers, most of whom are employed in service-producing industries, make up the fastest growing occupational group. Factors expected to increase the need for these workers are the rising demand for health services, commercial cleaning services and--as incomes rise--more frequent use of restaurants, beauty salons, and leisure services. Between 1980 and 1990, employment of service workers is expected to increase by about 24 to 32 percent from 14.6 million to between 18.1 and 19.2 million workers.

College Graduates

Turning to one segment of the future job market--the expected outlook for college graduates--the job market for college graduates during the 1980's is expected to be similar to the highly competitive market that characterized the 1970's. There are several reasons for the projected imbalance between the number of entrants to the supply of college graduates and the number of job openings that will require at least a 4-year degree. These involve factors influencing the supply of college graduates, the college labor market of the 1970's, and occupational demand in the 1980's.

SUPPLY OF COLLEGE GRADUATES. The supply of college graduates over the 1980-90 period will be strongly influenced by trends in the population, education, and the labor force.

Population trends. Although the Nation's population will continue to grow at a modest rate during the 1980's, major changes in its composition will occur--reflecting dramatic changes in the birth rate over the past 35 years. Today, the leading edge of the baby-boom bulge is in its midthirties, while the trailing end is in its early twenties. The proportion of the population between 16-24--the typical ages for college attendance--will decline in the 1980's. The population between 16 and 24 years of age is expected to drop by about one-sixth during the 1980's, from 37.6 to 31.5 million.

Education trends. Since the baby-boom generation began entering the labor force in the mid-1960's, the amount of education completed by workers has increased substantially, as shown in the tabulation below.

	Percent distribution	
	1965	1980
Labor force--total	100.0	100.0
Less than 4 years of high school	41.4	20.5
4 years of high school	36.4	41.9
1 to 3 years of college	10.6	18.6
4 or more years of college	11.6	19.0

The proportion of workers who did not have a high school diploma shrank to less than half its original size between 1965 and 1980. The proportion of workers who completed postsecondary education grew as the baby-boom generation sought higher education in unprecedented numbers.

This growth in the educational attainment of the labor force is to a great extent the result of growth in the number of college graduates. The number of bachelor's degrees awarded increased from 502,000 during the 1964-65 school year to 929,000 during the 1979-80 school year, an increase of more than 85 percent. The number of bachelor's degrees awarded annually is expected to increase slowly during the early 1980's, but as the baby-boom cohort passes out of the typical ages of college attendance, the number of degrees granted annually is expected to fall.

The College Labor Market of the 1970's. When those in the baby-boom generation began receiving their bachelor's degrees in the late 1960's, the supply of college graduates—those either employed or looking for work--roughly balanced the number of jobs requiring a college degree. The total impact of this generation on the job market was delayed for several years, however, as many entered military service or pursued graduates studies. But beginning about 1970, the job market for college graduates deteriorated. As the Vietnam conflict wound down, the number of college graduates in the Armed Forces began to drop. The job market suddenly changed when these graduates began entering the labor force from the military and from the Nation's graduate schools. As the baby-boom generation flooded into the labor force in the 1970's, armed with college diplomas, the supply of college graduates began to outstrip the number of openings in jobs that traditionally had required a college degree.

Requirements for college graduates failed to keep pace with the supply in this period for two principal reasons. First, as the baby-boom generation began leaving school, school enrollments began to fall and employment growth in that sector began to slow. Since nearly one-fourth of all college graduates employed in 1970 were elementary or secondary school teachers, the impact was significant. Over the subsequent decade, teacher employment grew only one-fourth as fast as college graduate employment in general. Second, overall economic growth slowed during the 1970's. Particularly affected were many high-technology industries, another important source of jobs for college graduates. As fewer new jobs were created, an imbalance emerged between the supply of college graduates and the demand for them.

The occupational employment pattern of college graduates changed greatly during the 1970's, as the tabulation below illustrates.

Employment of college graduates	Percent distribution	
	1970	1980
All occupations	100.0	100.0
Professional and technical workers	76.0	55.0
Managers and administrators	16.6	19.5
Sales workers	5.3	6.8
Clerical workers	6.3	9.0
Craft workers	1.8	3.3
Operatives	1.1	1.4
Laborers	0.2	0.8
Service workers	1.1	3.3
Farm workers	0.6	0.9

The overflow of college graduates into occupations that had not traditionally required college degrees is even more evident when one examines the jobs entered by college graduates joining the labor force between 1970 and 1980. Only about 48 percent of the approximately 1.4 million college graduates who entered the labor force annually--on average--found professional and technical jobs. About 19 percent entered managerial and administrative occupations and about 6 percent entered nonretail sales jobs. In all, nearly 75 percent of the graduates who entered the labor force during the 1970's found jobs in these three occupational groups that have traditionally employed substantial proportions of college graduates. The remainder entered retail sales, service, farm, and blue-collar jobs, occupations that had employed few graduates in the past. About 5 percent found work in the small number of these jobs that generally require a college education; but the great majority of graduates who took jobs in these occupations entered positions that did not require a college degree for entry. In all, about 1 out of 5 graduates who joined the labor force during the 1970's either entered a job which did not require a college degree or experienced unemployment.

OUTLOOK FOR THE 1980's. College graduates entering the labor force during the 1980's are expected to encounter job market conditions very similar to those faced by entrants of the 1970's. About 15 million college graduates are projected to enter the labor force--about 60 percent are expected to be new graduates. Most of the remainder are expected to be reentrants--college-educated workers who left the labor force to raise a family, to pursue graduate education, or for other reasons.

Depending on the amount of economic growth realized by the economy as a whole and employment growth in college-graduate-dominated occupations in particular, between 12 And 13 million graduates are projected to be required during the 1980's.

About 67 percent of the graduates are expected to be required in professional and technical occupations and 28 percent in managerial, administrative, and sales occupations. The majority will be needed to replace college graduates who are expected to retire or leave the labor force for other reasons over the period.

A surplus of between 2 and 3 million college graduates is expected to enter the labor force during the 1980's. If the economy grows as slowly as it did during the 1970's, the surplus would be the higher figure, an average annual surplus of about 300,000 college graduates--about 1 graduate in 5, just as in the 1970's. If the economy grows more rapidly than it did in the 1970's, the average surplus would be about 200,000 college graduates--about 1 in 7--each year.

Even with more rapid growth, however, the job market experienced by college graduates in the 1980's is unlikely to be more favorable than in the 1970's. In 1980, a surplus of college graduates estimated at 3.8 million was already in the labor force, either employed in jobs that did not require their level of education or unemployed. Of course, many of these have since begun satisfying careers in occupations that do not require 4 years of college education. Others, however, can be expected to compete for jobs that more fully utilize their education. The job market will be more competitive to the extent that this pool of underemployed 1970's entrants competes along with 1980's entrants for job openings requiring a college degree.

Like college graduates in the 1970's, future college graduates cannot be assured that they will find jobs in the occupations of their choice. Many may experience periods of unemployment, have to relocate to other areas of the country, or job-hop before finding one that satisfies them. As in the 1970's, some may have to compete with nongraduates for the more desirable jobs not previously filled by graduates, but in many cases, their additional education will prove to be an advantage. Even though a college degree may not be required, many employers prefer to hire the best educated candidate who is qualified for a job. In many cases, a college graduate will also have an advantage in gaining promotion in non-college careers over those without degrees. Many graduates who are forced to start work in jobs for which they are over-qualified nevertheless may gain useful experience that will be an advantage in competing later for more challenging jobs. Graduates who make a wise career choice and who are best prepared to enter the job market should make a smooth transition from school to work. Those who are not will end up scrambling for the best available jobs. Most graduates, however, will probably find a job and few should face sustained unemployment.

While the overall supply of college graduates exceed expected demand in the 1980's, ~~the~~ supply-demand picture for individual fields differ greatly. Some such as computer science and engineering are projected to be in short supply, while other fields are expected to have large surpluses. A college degree is not the reliable ticket to a good job that it once was, but it nevertheless is a prerequisite for a growing proportion of jobs. The other benefits of a college education remain, however, including opportunities for learning, personal development, and broadening interests.

DIFFERENT PERSPECTIVES ON FUTURE JOB MARKET. In looking to the future there are a number of different ways one can categorize job growth. The first of these is to list those jobs with the most rapid rates of growth. Such lists are contained in the following three tables.

Table 1

Fastest Growing Occupations For Which
A High School Diploma or Less is Adequate Preparation

Occupation	Projected Percent change in employment, 1980-90	Employment, 1980 (in thousands)
Food preparation and service workers, fast food restaurants	50-57	806
Correction officials and jailers	47-49	103
Nurses' aides and orderlies	43-53	1,175
Psychiatric aides	40-46	82
Dental assistants	39-42	139
Painters, automotive	38-44	41
Claims clerks	36-42	68
Dry wall applicators	35-46	52
Child care attendants	35-45	41
Insurance clerks, medical	35-41	29
Tapers (dry wall)	34-44	32
Welfare service aides	34-39	95
Statement clerks	34-38	33
Housekeepers, hotel and motel	33-46	50
Washers, machine and starchers (laundering, drycleaning)	33-46	59

Source: Occupational Projections and Training Data, BLS Bulletin 2202, December 1982

Table 2

Fastest Growing Occupations That Generally Require Postsecondary Education and Training (But Less Than a Bachelor's Degree)

Occupation	Projected Percent change in employment, 1980-90	Employment, 1980 (in thousands)
Paralegal personnel	109-139	32
Data processing machine mechanics	93-112	83
Computer operators	72-83	185
Office machine and cash register servicers	60-73	55
Tax preparers	49-70	31
Employment interviewers	47-64	58
Peripheral EDP equipment operators	44-52	49
Travel agents and accommodations appraisers	43-52	52
Claims agents	43-46	40
Brickmasons	40-51	146
Nurses, professional	40-47	1,104
Surgical technicians	39-45	32
Dental hygienists	39-42	61
Health records technologists	38-44	32
Concrete and terrazzo finishers	37-47	113

Source: Occupational Projections and Training Data, BLS Bulletin 2202, December 1982

Table 3

Fastest Growing Occupations
Requiring a Bachelor's Degree

Occupation	Projected Percent change in employment, 1980-90	Employment, 1980 (in thousands)
Computer systems analysts	68-80	205
Physical therapists	51-59	34
Computer programmers	49-60	228
Speech and hearing clinicians	47-50	35
Aero-Astronautic engineers	43-52	68
Economists	42-50	29
Dietitians	38-46	44
Electrical engineers	35-47	327
Medical laboratory technologists	34-42	105
Architects	33-41	80
Veterinarians	31-41	36
Law clerks	30-47	33
Geologists	30-38	40
Mechanical engineers	29-41	213
Psychologists	29-35	82

Source: Occupational Projections and Training Data, BLS Bulletin 2202, December 1982

An important dimension of these occupations, however, is that a number of these rapidly growing occupations are relatively small so that very rapid rates of growth still may involve, in absolute numbers, a relatively small number of jobs.

The following list contains those occupations with the largest numerical growth projected over the next decade. As can be seen from this list, the occupations listed contain only a few of those that were listed among the most rapidly growing, reinforcing the point that rapid growth often takes place from a relatively small employment base. Thus, in considering future needs of the economy for workers of various skills, both dimensions need to be kept in focus--the most rapidly growing and those which may numerically provide the most jobs.

Table 4

The Following Occupations Will Account For 50 Percent Of All New Jobs Generated During The 1980's

Occupation	Projected Growth in Employment 1/ 1980-90 (in thousands)
Secretaries	700
Nurses'aides and orderlies	508
Janitors and sextons	501
Sales clerks	479
Cashiers	452
Nurses, professional	437
Truck drivers	415
Food service workers, fast food restaurants	400
General clerks, office	377
Waiters and waitresses	360
Elementary school teachers	251
Kitchen helpers	231
Accountants and auditors	221
Helpers, trades	212
Automotive mechanics	206
Blue-collar worker supervisors	206
Typists	187
Licensed practical nurses	185
Carpenters	173
Bookkeepers, hand	167
Guards and doorkeepers	153
Stock clerks, stockroom and warehouse	142
Computer systems analysts	139
Store managers	139
Physicians, medical and osteopathic	135
Maintenance repairers, general utility	134
Computer operators	132
Child care workers, except private household	125
Welders and flamecutters	123
Stock clerks, sales floor	120
Electrical engineers	115
Computer programmers	112
Electricians	109
Bank tellers	108
Electrical and electronic technicians	107
Lawyers	107
Sales agents and representatives, real estate	102

1/ Low alternative only, other alternative models give differing numerical levels but do not change in any substantial way the rankings nor the percent of jobs represented by this list of occupations.

Source: Occupational Projections and Training Data, BLS Bulletin 2202, December 1982

Highlights. The projections that I have just described provide insights into a variety of topics. I would like to highlight two points which may be of importance to this Subcommittee. First, most job openings will occur in existing occupations with the large majority in a relatively few fields. Although the Bureau has estimated employment in well over 1,000 occupations, about one-half of all job growth is projected to occur in only 37 occupations, as indicated in the table above. And, as can be seen from this list, many of these jobs will be in occupations that do not require extensive training. This same point is further emphasized by looking at the computer related occupations which over the last decade were among the more dynamic in the economy. Five occupations closely associated with the computer (programmers, system analysts, other computer specialists, computer operators, and keypunch and other data entry workers) experienced employment growth rates 1972-82, of 138; 227; 477; 200; and 28 percent respectively. Yet, overall, these five occupations only accounted for slightly over 5 percent of job growth over the period.

The second point, which these hearings are bringing into focus, is the expected impact of robots and other changes in programmable automation which likely will be introduced this decade at an increasing rate. Many of the jobs in the economy listed in Table 4 will be affected very little, if any, by these changes. Others, such as secretaries, may see a substantial impact in the manner in which they do their work changed with less impact likely on the number employed. A few such as production painters and welders could see substantial impact on their future job prospects. However, past studies made by the BLS on automation in this country have shown that its introduction is most often timed during periods of growth in demand so that the related job impacts, if necessary, is much easier to adjust through attrition. Further, of course, to the extent changes in production procedures lower unit costs, the resulting increases in demand for the product or service may be high enough to actually sustain a level or an increasing employment base.

Mr. Chairman, thank you very much for inviting me to testify. This concludes my portion of today's testimony. At this time I will be happy to answer any questions that you or other committee members may have.

Mr. **Bedell**. Thank you very much, Mr. Kutscher.

Mr. Bilirakis.

Mr. **Bilirakis**. Sir, I apologize for coming in late for the first part of your testimony.

The job openings that you project are based on job needs, is that correct? Job vacancies?

Mr. **Kutscher**. Well, they're based on our projection of job requirements, that's right. That's based on a set of economic projections that look at the economy. In fact, the reason we have ranges around those rates of growth is that we look at the economy under different sets of economic assumptions. You get a lower or higher growth, depending on what set of economic assumptions you make about the future.

Mr. **Bilirakis**. I really only had one question, and that was what type of jobs do you anticipate being replaced by robots? How do you determine these projections, as a result of surveys, questionnaires, and whatnot, with employers?

Mr. **Kutscher**. No, the projections are not. The projections are developed based on economic models and data bases that are fit to historical data that are provided us by employers. For example, our industry data allows us to analyze the movement of goods throughout the economy, but if you produce an automobile, there are a number of inputs required to make an automobile and this type of model is called an input/output model. It traces the demand for automobiles and associated with that is all of the raw materials, inputs of goods or services required to make an auto. We estimate the share of that between domestic and imported, and then in order to make an automobile, you need steel, glass, rubber. You need tires, you need iron ore, and textiles, and all of the other goods and services that go into an automobile.

So our model allows us to translate estimated automobile demand into the demand required in the steel industry, which we then in turn translate that into employment in the steel industry. We also have what we call an industry occupational matrix, which is the staffing pattern for all of the skills required in the auto industry, the steel industry, the iron ore industry, the chemical industry, in the wholesale trade industry, and in retail trade.

Our data over time allows us to see how these skills change. Obviously, skills like computer related skills are increasing over time. So we project those to have a higher share of jobs in each of these industries, but the overall demand then for employment, first in the auto industry, and then in the occupation, is related back to how many autos will we produce, or how many ships, or boats, or how much output of the advertising industry we'll have, the industries that supply inputs to that, the people they need, and the skill composition that we expect them to have in the year 1990. So that we're projecting how technology will affect the economy in two ways.

First, in the economic model, the input/output model. These relationships among industries change due to technological change.

Second, in the industry occupational matrix, the skill composition changes due to changes in technology, so that when we go into an industry like autos, we'll change the staffing pattern for production painters, and welders, particularly for the next set of projections we're doing, because the expectation is that robots will lower the need for the number of workers of this type in the auto sector.

That was a very long answer, but I hope it has addressed our question.

Mr. BILIRAKIS. It's a good answer.

So your forecast on the use of robots for welders, and such occupations, is all a part of your matrix?

Mr. KUTSCHER. Right.

Mr. BILIRAKIS. Thank you, sir. I have no further questions.

Mr. BEDELL. Mr. Schaefer.

Mr. SCHAEFER. No questions.

Mr. BEDELL. Mr. Kutscher, what projections did you use for the growth of the GNP, and growth of productivity over this 10-year period?

Mr. KUTSCHER. Well, as I mentioned to the previous question, we in fact, have alternatives. The low rate of growth of GNP is 2 per cent for this decade, and the rate of productivity growth is 1.3 percent. On the high side, our projections are 3.9 percent annual growth in real GNP, and, I believe 1.9 to 2 percent growth in productivity.

Mr. BEDELL. How did you arrive at those figures, because they seem awfully high to me, compared to what we've had recently.

Mr. KUTSCHER. Well I think the lower side of those are fairly close to the performance, particularly on the GNP side, for the decade of the seventies.

The higher one is roughly equivalent to what we had in the sixties.

Now, on the productivity side, you're correct. Both of those projections are higher than recent historical experience. I think arriving at that estimate, we looked at the factors that have affected productivity growth, and we think that in the 1980's the opportunity for productivity growth is higher than, or better than it was in the 1970's, specifically changes made in investment law, should encourage more investment in this decade.

Mr. BEDELL. But we haven't seen that at all?

Mr. KUTSCHER. We haven't seen it yet.

Mr. BEDELL. Going just the other way, in spite of those, is that right?

Mr. KUTSCHER. That's right today. That's true, although again, that's a typical behavior in a business cycle, is for business investment to lag the recovery in an economy. So that if there is a benefit from investment tax changes, it's something one would expect to happen in 1984, 1985, and beyond, but you're absolutely right. It hasn't happened yet.

The other factors that we believe would work toward higher productivity growth this decade is the expectation in areas like energy the future price changes that the economy can expect in energy are not like we had to absorb in the 1970's. So an awful lot of business investment in 1970 was directed toward energy savings rather than productivity enhancing type investment.

The other element in the productivity that led us to believe we'll have a somewhat higher rate, is the absorption of the large number of young people, is already behind us. So the future growth in the labor force will tend to be a more mature, more educated, more experienced work labor force than what the economy was working with in the 1970's.

Mr. **Bedell**. I'm advised that the average real increase in GNP for our last 5 years was 1.5 percent. The projection for the next decade is higher than that, but I think roughly equivalent with the seventies, the entire decade of the seventies, from 1970 to 1980.

Do you think the next 10 years will be somewhat similar to the 1970's then?

Mr. **Kutscher**. Well, that's what we were exploring in one alternative. In another one, we explored something higher than that.

Mr. **Bedell**. That's what I mean. There will be an equivalent to that.

Mr. **Kutscher**. Or it could be higher.

Mr. **Bedell**. That's our boom time that we had there? Apparently you think that's realistic.

Mr. **Kutscher**. Yes, I think that encompasses the range of what most analysts reviewing long-range trends are projecting for the future.

Mr. **Bedell**. You said your projection here by 14 percent in some areas——

Mr. **Kutscher**. That's the average error; that's right. In fact, if you go back and look at the detailed evaluation, there are some occupations that we error by 70 and 80 percent.

Mr. **Bedell**. What were those?

Mr. **Kutscher**. I'm told that plasterers is one of the types of occupations we errored a lot on. They tend to be either occupations which are small, or radical change is taking place on it. We can provide for the record others that we had very large errors in. In the 1980 projection, large projection errors were made for locomotive engineers helpers, credit managers, telephone operators, and airplane mechanics and repairers.

Mr. **Bedell**. Yes; I noticed in your projections you indicate that many of the building trades you expect big increases in the number of people employed.

Apparently you don't project any particular improvement in productivity in those areas than you project——

Mr. **Kutscher**. A fairly moderate——

Mr. **Bedell**. Quite a boom in building over the next 10 years, is that right?

Mr. **Kutscher**. Yes.

Mr. **Bedell**. I think we better adjourn for maybe 10 minutes, while we run over and try to vote.

Mr. **Kutscher**. OK. Surely.

[A short recess was taken.]

Mr. **Bedell**. The committee will come to order.

Mr. Kutscher, you said that you had estimated a low GNP growth of 2.5 percent, and a high one of 3.9.

Mr. **Kutscher**. Yes.

Mr. **Bedell**. When did you make those?

Mr. **Kutscher**. Those projections were published in August 1981. They were scheduled for updating in the fall of 1983 on our 2-year cycle.

Mr. **Bedell**. Do you have any idea at this time whether those will be changed up or down?

Mr. **Kutscher**. It's really too early to tell. We have progressed for, but haven't arrived at, the final answers. I would think the range would roughly cover what we would have. We may modify some internal projections but that the range probably will not change a lot.

Mr. **Bedell**. You really have the figures now that you will have then, except for monthly figures, don't you? Annual figures are all in that you would have, are they not?

Mr. **Kutscher**. You mean historical data?

Mr. **Bedell**. Yes.

Mr. **Kutscher**. That's correct. We now have all of the historical data we will use in the current set of projection.

Mr. **Kutscher**. But in developing projections, historical data is one of the elements. The other element is our judgment on how the historical pattern will be modified in the future, just like I described to you on productivity. We didn't use the historical pattern. We modified it.

We do that for many other elements in the projection, both based on our judgment, and judgments we can get from outside users of our material.

Mr. **Bedell**. I presume you're aware of the testimony we had yesterday?

Mr. **Kutscher**. Yes.

Mr. **Bedell**. It was critical of two things in your projection. One was there was criticism of the way you gather your data. I don't know if that's justified or not, but they said that it had also been criticized by some group that had surveyed it. Are you aware of that?

Mr. **Kutscher**. Well, I'm aware of Mr. Helms' criticism of our data. I think if you would go back and look at it——

Mr. **Bedell**. The National Commission for Employment and Unemployment Statistics issued their report counting the labor force in 1979.

Mr. **Kutscher**. I think that if you would read that entire report you would find that it's largely an endorsement of the procedures that BLS used to collect employment and unemployment date.

There was some recommendations there for modifying certain things, which BLS has already incorporated, such as counting the military as being employed, adjusting to the 1980 population base, and other elements. I guess I would characterize that Presidential commission as 99 percent endorsing what BLS is doing, as the best——

Mr. **Bedell**. I think we should get a copy of it.

Mr. **Kutscher**. Yes, surely; you make the judgment yourself. That's the way I would characterize it.

Mr. **Bedell**. He was also very critical of the Dictionary of Occupational Titles. Do you concur in his criticism there?

Mr. **Kutscher**. Well, I guess frankly, the Dictionary of Occupational Titles has so little impact on what we do that if his criticisms are valid, he overemphasizes the impact that it has on us. The only place we show the Dictionary of Occupational Titles is as final note in our Occupational Outlook Handbook. We list an occupation, and for use by individuals that want to cross-reference our projections with other data, we list all the Dictionary of Occupational Titles that fall into each occupation covered in the Occupational Outlook Handbook.

Now, if those are wrong or in error, as he claims, it would make it difficult for someone to cross-classify our projections with other systems. But the Dictionary of Occupational Titles does not affect the data we have. It does not affect the manner it's collected, nor does it affect in any way our projections procedures.

Mr. **Bedell**. You collect it by telephone to households?

Mr. **Kutscher**. Well, there's two different data sets. In fact, there may be three that should come into play: One is the household survey, that is a survey done by the Bureau of the Census for the Bureau of Labor Statistics.

Mr. **Bedell**. How many households do they——

Mr. **Kutscher**. That's 60,000 households each month on a rotating basis. Now that is collected usually by personal visit on initiation. A household is in for 4 months, out for 8 months, and back in for 4 months.

The first visit, the first initial collection is usually done by personal visit.

Mr. **Bedell**. Is that right?

Mr. **Kutscher**. And then followup surveys are generally done by telephone.

It's this household survey that's used to publish the monthly employment and unemployment data. When you see the BLS announce the unemployment rate as 10.1 percent, that's the data base that is used to collect that information.

Now, it is also true that as a part of that, individuals are classified into occupations. But individuals are not asked to classify themselves. They're asked what work they do, and then professional classifiers at the Bureau of the Census categorize that work into an occupational classification.

In addition to that, the Bureau has two other data bases. We have our employment by industry data base. These data come from a monthly sample of employers who regularly report to the Bureau of Labor Statistics each month, and that sample is about 195,000 to 200,000 business establishments, on a monthly basis. Annually that data is benchmarked to the unemployment insurance records, which means that there's 4.8 million establishments in the unemployment insurance files, so that although the monthly data—which is a sample—could go off on a month-to-month basis, annually it's benchmarked to every establishment in the United States that report to the unemployment insurance system.

Finally, we have an occupational employment statistic survey from which we collect occupational patterns. This surveys a sample of one-third of businesses annually. And the total sample in the 3-year cycle is roughly 600,000.

Mr. **Bedell**. Will that business survey include their projection what employment they expect in the future?

Mr. **Kutscher**. No; we do not collect from them their anticipated——

Mr. **Bedell**. Are you acquainted with the article that was in the New York Times? It came to my desk this morning concerning Business Round Table meeting in Hot Springs, Va.

Mr. **Kutscher**. Yes; I am familiar with that.

Mr. **Bedell**. They said that even though they expected to improve their production, they did not expect to hire the laid off workers; they expected to make changes where it would not require——

Mr. **Kutscher**. I would characterize that as probably a very realistic look at the near-term prospects in manufacturing. Significant gains in near-term output, with employment gains likely to come very slowly. Of course the other side of that is you're talking only about big business. And there's some increasing data which infers an awful lot of employment gains in the United States come from small business, not from large business.

Mr. **Bedell**. So would you expect that in the near term, if we do have some economic recovery, as it looks like we're having right now, that we would have a significant improvement in our unemployment figures?

Mr. **Kutscher**. Well, we ususally don't make short-term forecasts. Consistent with what the Business Round Table is saying is the improvement in the unemployment would be slow, if you get improvements in business. But they're slow to bring back people; then the unemployment rate can't improve very rapidly.

Mr. **Bedell**. The other criticism that came forth was, if I understood it correctly, that there was a feeling that the impact of automation, not just robots, but all automation, including computerization, and so on, had not yet been felt. If we go by the historical data which you do, it was not going to take adequate account of the changes that we can expect in the future. At least some of the witnesses we had yesterday felt that that's going to be much more rapid than it's been in the past. How would you comment on that criticism?

Mr. **Kutscher**. I guess our past experience in the Bureau, where we do have a program that studies the introduction of automation, and how that's introduced, leads us to believe that most technological changes are diffused slowly, and that the adjustment process is gradual.

Even though the impact of computers and robots are yet to be felt, I guess our best judgment is these will be brought on slowly, and the impact will be diffused over a fairly long period of time.

Mr. **Bedell**. It seems to me that ought to be the major debate that should be considered here, because I notice that you list the jobs in which we will have the greatest growth among others: secretaries, typists, stock clerks, and stock room and warehouse people. At least some of the people that testified yesterday would say that would be some of the areas in which we would see automation take its heaviest toll. With computers you won't need so many stock clerks and so on, because it'll all be done automatically with computers. Typing will be sufficiently automated, that you won't need as many typists, and we won't use as many memos, and written messages, because it will be communicated in other manners with the automation that we're going to have.

It seems to me that it is an argument we need to look at, and your answer indicates to me you simply disagree with him, and we sure better find out who's right, because we're depending upon your figures because they are generally the base from which most work is done.

If you're making an incorrect assumption in that regard, then I think it's a pretty critical issue, frankly. I'm not saying you are or not, but I'm telling you that there were people yesterday that said robots are of secondary importance. The really important thing is what we're going to see happening with computers, and this type of automation, which is going to cut down so much on other jobs. They even said there's going to be significant cutback in white collar workers in our society. I'm not saying who's right, but I thought you ought to be aware. I think that's a major issue that somebody needs to address.

Mr. **Kutscher**. I guess to some extent I would say that I disagree with them only in degree.

Mr. **Bedell**. It's a pretty big degree, if you say secretaries are going to be the occupation that's going to have the greatest growth of any occupation in our whole society, and they would say that it's an occupation, I think, which is probably going to decline. That's not a little degree of disagreement.

Mr. **Kutscher**. Yeah, that is a radical—I guess on a job like——

Mr. **Bedell**. Democrats and Republicans, if you have that much disagreement.

Mr. **Kutscher**. I won't comment on that, but on jobs like secretaries, I guess our analysis of what word processing equipment is doing to jobs like secretaries, is changing the manner in which the work is carried out, but we have not yet seen anything that would indicate, at least up to 1990, an impact that will radically alter the numbers of secretaries who will be used.

Now, that's different than robots, where when you introduce a robot, you don't need a welder to do that work. A lot of the functions that a secretary carries out are not related to typing. It's true that a word processor makes the typing function of a secretary more efficient.

Mr. **Bedell**. But you list typists, just plain typists, about 15th on your list, so you could say secretaries don't spend all their time typing, but you also say typists are going to be—it must be about right at very near the top of those professions—where the biggest increase in people will be required.

Mr. **Kutscher**. This is back to an argument as to the speed in which these changes will take place. I think down the road you will see the number of typists tend to level off and go down due to these technological changes. Just like we already see a function taking place like that. It's happening on the computer side, and that's on data entry. Technology is displacing the need for a lot of keypunch operators, so keypunch operators are not growing much, in fact much slower than all other computer-related occupations. Probably sometime this decade they will absolutely level out and start declining. I wouldn't expect to see that for typists, but I guess my argument is I think that is a phenomenon which will take place in the 1990's, and not in the 1980's.

Mr. **Bedell**. Well, this gets at the whole issue.

Mr. **Kutscher**. Yeah.

Mr. **Bedell**. I don't think anybody is questioning your sincerity; at least I certainly am not. I think when we really get to the bottom line, what we're really saying is, that no matter how well you may collect the data, if you project our GNP growth to be somewhere between 2.5 and 3.9, and if it has been practically zero for the last 4 years, and if you are wrong, then your projections are terribly wrong.

If the people happen to be right yesterday, who said we're just now starting to see the effects of computers in this sort of automation, this sort of thing in work replacement other than robots, and that you feel that's not going to be the case, then again your projections are terribly, terribly wrong.

I guess the concern I have is people look at you as a specialist because you are the ones that collect data the best of anyone, and I have no great argument with that. You collect the data so well, but then we say, "Since they're good at collecting data, they must therefore be good at projecting the future." That is subject to question, in all fairness, Mr. Kutscher, that you could be right, or you could be wrong. The other people could be right, or they could be wrong too.

But one problem comes in that you are sort of the god in that regard in that everybody says, "Well, since you're the only ones that collect the data, then surely you're the ones who we ought to believe when you say what's going to happen in the future."

Mr. **Bedell**. That's troublesome to me as a legislator.

Mr. **Kutscher**. We certainly tried to warn the users by the literature we put out that we are not godlike in terms of our wisdom about the future.

Mr. **Bedell**. But I think you are the ones that are accepted as the authorities in that regard and most everything, as near as I can tell, is based upon your projections.

Mr. **Kutscher**. A lot of the occupational projections do derive from ours; there's no question about it. We try to do as careful a job as we can. It is something on which reasonable people can very easily have a different opinion.

Mr. **Bedell**. Did you have something?

Mr. **Fithian**. Just on this particular thing, if I may, Mr. Chairman.

Mr. Kutscher, when you take historical data, which I understand you're working with ratios up about as recent as 1977 or thereabouts, you tend to project on the same line that you've been on. If that is true and the basic ingredient, then it seems to me likely that you would miss either an upswing or a downswing; you would miss the curve. You would be projecting on out and miss the curve. The sharper the curve, in years ahead, the greater the rate of error is likely to be.

That is, I guess, my problem. As I look at the past, the last 5 to 7 years, and you talk to all kinds of people, even people who want to speak for this administration, or the last administration optimistically, they come up with some very, very ominous kinds of figures in unemployment, yet that would not be reflected in your data. Your data is optimistic in the sense that every occupational group is going to be increasing.

Let me give you a specific example: Yesterday we talked about the occupation of draftsman. Most people looking at the field say that is, at least, going to be cut in half by computer-aided design, but when we go to your projections, it still projects growth. It seems to me that's the phenomenon of this projecting on a line in which we've been moving in the past, and making it very unlikely that you would catch a sharp, even 3- or 4-year turn, right at the present. So that at the most critical time that the Congress needs guidance, your methodology would by its very nature lead them astray.

Mr. KUTSCHER. I guess I would react in this way: Catching turning points is by far the most difficult thing in forecasting the future. I don't know whether our methodology is any better than the alternatives. We try to search for the best methods. We look at the historical trend, and in cases where we judge its wrong, we don't extend it out. We modify it and turn it, but I would be the last to admit we have the ability to always capture every turning point of every occupation.

If you look at those places where we made the most error—plaster was given as an example. Something happened to plastering back in the 1960's and 1970's that radically altered the demand, and we missed that turning point. We could be doing that here. On cases like draftsmen, it's a case that if you look at how fast will the technology diffuse, most technologies are diffused at a moderate rate because business incorporate the new technology when it will pay for itself.

So that even though it's there, even though it has some cost advantages, some labor saving, everyone doesn't immediately grab it. On an occupation like draftsman, again it's a question that the demand for draftsman is going to be changed by CAD/CAM type equipment. The question is, will people fire draftsmen and go out and buy the equipment, or will they introduce it gradually.

I guess our judgment is they will be gradually introduced. The rate of growth of draftsmen will slow, come to a halt sometime, and then level off and turn down, but we would put that in the early 1990's rather than between now and the end of the decade.

Again, albeit an important degree of difference, we don't think it is not going to happen. It's a question, again, as to when it will happen.

There's also something else related to computer assisted design for drafting, and that relates to technology, like the computer, and a variety of other technologies, in which you can actually, by virtue of the technology, you can do more work, and actually increase employment because there's so many more things you can do.

The computer has done that in the field of economics and statistics. There are so many more things you can do, and employment actually grows because there's more output, more things to do.

That can also happen, that's part of our judgment, in the growth of drafters because there are more things that can be done, as well ~~as~~ improving efficiency.

Mr. BEDELL. We thank you very much for your testimony, Mr. Kutscher.

Mr. KUTSCHER. Thank you.

Mr. BEDELL. Mr. Conte, would like to introduce the next witness.

Mr. CONTE. Mr. Chairman, it's a pleasure for me to welcome Ms. Katharine Abraham, a professor at MIT to Washington. She just completed a study in the number of jobs, and the number of people looking for jobs, and I don't want to steal her thunder by telling her conclusions now. But I'm going to listen very closely to see how she reached these conclusions.

I recently read a very fine article in the Washington Post about your work, Professor Abraham, and it's a real treat for us to have you here. We welcome you here.

TESTIMONY OF KATHARINE G. ABRAHAM, ASSISTANT PROFESSOR, SLOAN SCHOOL OF MANAGEMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Ms. **Abraham**. Thank you very much. Mr. Chairman, I have a prepared statement which I'd like to submit for the record, if that will be possible.

Mr. **Bedell**. Without objection, your whole statement will be entered in the record, and we'd welcome any summary that you'd care to make.

Ms. **Abraham**. Let me say also I'm particularly pleased to have been invited to testify before this subcommittee, since I'm the product of an Iowa childhood and a graduate of Iowa State University. I have more than one connection here.

Mr. **Bedell**. We do know where that is, of course.

Ms. **Abraham**. I'll just briefly go through the testimony that I have written out, and then I'd be delighted to answer any questions you might have concerning my statement.

President Reagan has commented on numerous occasions that when he picks up his newspaper there are many pages of help wanted ads. Implicit in this sort of comment is the conclusion that something other than a shortage of employment opportunities is the real culprit in our current unemployment situation. I think this conclusion appears unreasonable to most observers. My own work looking into how the number of jobs available compares to the number of people unemployed has convinced me that it is very far off the mark indeed.

My examination of the best available evidence has led me to conclude that at the present time the number of unemployed persons most likely exceeds the number of jobs available by a factor of 10 or more.

What I'd like to discuss with you this morning is the evidence that has led me to this conclusion and what I think this conclusion implies. To resolve the question of how the number of jobs available compares to the number of people unemployed, we obviously need information both on unemployment and on job vacancies.

We have very good data on unemployment from the monthly Current Population Survey reports. The Current Population Survey is the household survey that the previous witness was discussing. These reports are based on interviews each month with members of approximately 60,000 households across the country concerning their labor force activities and other matters.

There is unfortunately no ongoing survey of employers to provide us with comparable information on the unsatisfied demand for labor, or the level of job vacancies.

I'd like to comment, as an aside, that indeed we lack good information on most aspects of employers' labor market position. Until quite recently, information on hires, quits, and layoffs in the manufacturing sector was collected on a monthly basis. The survey that provided even this relatively limited, but still quite useful, information was discontinued as of December 1981. It seems clear to me that better information on employers' labor market needs could be of considerable assistance in the policymaking process. I would argue quite strongly that the Bureau of Labor Statistics ought to be given funding for the purposes of collecting this sort of information. But that is, as I said, an aside from my main point.

While it is unfortunate that we currently operate no ongoing survey that provides us with information on job vacancies, U.S. and Canadian employers have provided usable information on job vacancies in connection with six different pilot projects and longer term survey efforts that have been undertaken since the midsixties.

These sources of information on the level of job vacancies in particular areas and at particular points in time can be used to estimate the job vacancy rate associated with different unemployment rates. Given that relationship, we can make a good estimate of the number of jobs available at our current unemployment rate.

The available information on job openings has been collected through surveys sent out to employers. As I said, there have been six such survey efforts. The first was a pilot project done by the Bureau of Labor Statistics in the midsixties, which produced data for about 15 cities, covering roughly 25 percent of the Nation's total employment.

We collected job vacancy data for the manufacturing sector nationwide from April 1969 through December 1973. The States of Minnesota and Wisconsin have continued to collect comprehensive job vacancy data up through at least December 1981.

The Bureau of Labor Statistics ran a more recent job vacancy pilot program that yielded some information for 1979 and 1980. And in Canada, a very comprehensive and careful job vacancy survey was conducted from 1971 through 1978. So those are the sources of data that we have on the job vacancy rate.

This information on job vacancies has received less attention than I believe it warrants. I would guess that the primary reason for this neglect is that the existing job vacancy data are widely believed to understate the true number of available positions.

There are a variety of arguments that people have advanced why this is true. People have argued there are a lot of discouraged vacancies, analogous to discouraged workers, jobs that employers would like to fill but that they've given up recruiting for because they can't find anybody. People have argued that employers are often willing to hire well-qualified individuals who present themselves off the street, even if they don't have a preexisting vacancy, and that counts of job vacancies would miss that kind of employment opportunity.

There have been more technical criticisms levied against the job vacancy surveys that were conducted; for example, people have argued that the samples of firms included in the surveys were not representative and tended to have lower than average vacancy rates, and that if a more representative sample of employers had been surveyed, a higher estimate of the job vacancy rate would have been obtained.

An important part of my research effort on this subject has been to collect information bearing on all of these various possible problems with the job vacancy statistics. I have then used this information to correct the published numbers, inflating them as appropriate to come up with more believable, more accurate numbers.

Whenever there was a question based on the information that I had about how important a particular problem was likely to be as a source of understatement in the job vacancy numbers, I assumed that it was more important, rather than less important. I also made no effort to adjust the published numbers for possible sources of upward bias.

Given that I was very generous in correcting for possible downward bias in the vacancy numbers and that I made no effort to correct for upward bias in the vacancy numbers, if anything, the numbers that I came up with are almost certainly too large, rather than too small.

I should also note that there is a check on the reasonableness of my corrections to the vacancy numbers. I performed some other calculations using a quite different approach and was reassured to find that the job vacancy numbers that I came up with using this alternative approach seemed quite consistent with the estimates that I've just described to you.

The corrected job vacancy numbers that I've just described apply of course only to the time periods, and the areas covered by the various job vacancy surveys that I mentioned. However, plotting the job vacancy rates obtained by this correction procedure against the unemployment rate for the same time periods and areas makes it clear that there is an inverse relationship between the job vacancy rate and the unemployment rate.

When the unemployment rate is low, employers tend to have many vacant jobs. When unemployment is high, employers tend to have few vacant jobs. The existence of an inverse relationship of this sort makes good theoretical sense. The general shape of the unemployment/vacancy relationship is as drawn in figure 1 included in my written statement.

If it can be assumed that the unemployment/vacancy relationship in the areas where vacancy data have been collected roughly mirrors the unemployment/vacancy relationship in the United States as a whole, and if it can be determined whether and how this relationship has changed over time, my data can be used to support conclusions about how the number of jobs available today compares to the number of persons seeking work.

All of the data seem pretty consistent, so that I think that it does make sense to draw conclusions from the survey data for the country as a whole. Other information has given me what I consider to be a pretty good sense of how the aggregate unemployment/vacancy relationship has shifted over time, so I feel comfortable going ahead and drawing the sort of conclusions that appear in my written statement.

Just to put a little historical perspective on this: Calculations using the corrected vacancy data that I came up with suggest that during the last half of the sixties, when the unemployment rate hovered within the 3.5 percent to 4 percent range, the number of job openings probably came close to equaling the number of unemployed people.

During the 1970's between 1970 and 1980, a period that included three recessions, and during which the unemployment rate averaged above 6 percent, there were probably an average of four or five unemployed persons per vacant job. As of April of this year, the unemployment rate, as you know, stood at 10.1 percent, meaning that there were over 11 million people without work and seeking a job.

My calculations suggest that the number of unemployed people currently exceeds the number of available jobs by more than a factor of 10. I should note that this conclusion holds even after I've made an adjustment in my straightforward calculations to take account of the fact that the unemployment/vacancy trade off may have worsened during the past 10 years. In terms of figure 1, this curve may have shifted to the Northeast over the past 10 years.

That is to say, my estimates indicate that U.S. employers are currently in a position where they would like to hire only about 1 million additional workers, while at the same time there are more than 11 million people unemployed. Even if every available vacant job could be filled instantaneously by an unemployed person, we would have achieved only a relatively small reduction in our unemployment count.

It should be remembered that the job vacancy numbers that underlie my calculations were very generously adjusted upward to take account of possible downward bias. I'd also like to note that the official unemployment rate, which is what I've used in my calculations, excludes large numbers of people who should arguably be counted.

If the current official unemployment rate of 10.1 percent were adjusted to reflect a part-time/full-time distinction in both hours desired and hours worked—this is basically getting at people who are involuntarily working part time rather than full time—and to reflect the number of discouraged workers that is, the people who say they would like to work, but have given up looking because they can't find a job, the unemployment rate would be roughly 50 percent higher.

I may have overstated the number of vacant jobs and understated the number of persons needing work, which means that there may very well be more than 10 people available to fill every vacant job.

I think my finding that the number of unemployed persons greatly exceeds the number of available jobs has important implications for policy decisions. I wouldn't want to argue against increased investment in well designed training programs or against other measures intended to improve the matching of unemployed people to available jobs; that sort of expenditure may very well be appropriate.

What I think the evidence that I've presented indicates, though, is that on their own, measures of this sort can have very little impact on the overall unemployment rate.

The main conclusion that I'd like to leave you with is the conclusion that large reductions in the aggregate unemployment rate are going to require the creation of substantial numbers of new jobs.

Mr. **Bedell**. Thank you very much, Professor Abraham.

Mr. Conte.

Mr. **Conte**. On your last remark on training programs, you sort of give a lukewarm endorsement.

Let me tell you about one little incident that's happened in my district.

Wang is coming into Holyoke, and as a result of a $2 million UDAG grant I got them last year, we broke ground last fall, and we'll open up in June. We'll hire 1,200 people. Holyoke today is maybe about one-third Puerto Ricans, many of them unemployed and unskilled. They came up and worked on potato farms, and in tobacco fields, and eventually stayed there. It creates a real problem in the community.

I was able to swing some money from labor to start a training program in Holyoke. I'd say 95 percent of the trainees are Puerto Ricans. Had it not been for that program when Wang opened up in June, the 1,200 new employees in Holyoke wouldn't have gotten a job. The result of that training program, they are going to be ready to go to work when the doors open. I think the training is very, very important, especially when we have this shifting structural problem in our industries here in the United States, in steel, and other industries. We better have some very good, strong training programs so that when the economy does turn around, and it gets into high tech, these people will be able to go to work.

Ms. **Abraham**. I certainly wouldn't argue with that conclusion. I do think that training programs may serve a very important role in redistributing opportunities. I also think that training programs may serve a very important role when undertaken in conjunction with stimulative measures or upswings in the economy to help us toward full employment.

But on their own, I think they are exceedingly unlikely to have much effect on the aggregate unemployment rate. If all you're doing is training, you may affect who gets the jobs, but I don't think you're going to have a very big effect on the overall unemployment rate.

Mr. **Conte**. Well, the point I'm trying to make is that all indications are, and all indicators show that the economy is going to turn around, and that it's already begun. There's been this tremendous shift in high technology in this country.

If these people aren't trained, they aren't going to get those jobs. They're not prepared to take those jobs.

Ms. **Abraham**. I think that's correct.

Mr. **Conte**. Somebody who has been working in a steel mill for 20 years, can't come out and step into a high-technology field, unless he's trained.

Thank you.

Mr. **Bedell**. Thank you, Mr. Conte.

I assume that you would not have any great argument with the fact that we are becoming a more highly technological society, and that our educational system and training should recognize that, and we should hope that we would train people adequately.

Ms. **Abraham**. No, I certainly wouldn't want to argue with that.

Mr. **Bedell**. I understand your argument. It is that if we think training people when there's 10 or 15 people for every job, is going to give all those 15 people jobs, then we're kidding ourselves. Isn't that your point?

Ms. **Abraham**. Right. That's exactly the argument that I'm making.

Mr. **Bedell**. You raised an interesting question; that is, how unemployment will infringe upon the frictionally unemployed. The question is, with these high unemployment rates, I assume that people are much more reluctant to leave jobs than they would have been in the past. Are we getting to where there's less instead of more flexibility? Did you look into that at all?

Ms. **Abraham**. I haven't really done an in-depth investigation of that.

Mr. **Bedell**. The problem is, if that is the case, that if society is moving rapidly in terms of job availability, individuals are moving the other direction and are less willing to make changes because of their need for security.

Ms. **Abraham**. When we used to have data on the quit rate, it was in fact true, at least in the manufacturing sector, that the quit rate was quite cyclically responsive. As the unemployment rate goes up, the quit rate goes down, which is supportive of what you're saying.

Mr. **Bedell**. One thing we're trying to look at here is what we can expect in the future as best we can guess from the data available, and what we see happening.

Your study primarily has had to do what has happened up until now, and what you see now.

Ms. **Abraham**. Right.

Mr. **Bedell**. Are you in a position to hazard any observations that you have as to whether the current unemployment situation is a cyclical thing, likely to improve, or whether it's a structural thing that's likely to be with us for some time, which I think is the major question we're really trying to get at here.

Ms. **Abraham**. I think it's some of both. The main thing I've focused in the written testimony that I submitted to you is what you might call the cyclical component of unemployment. There are a great many more unemployed people than jobs available and we need to worry about that.

I think it's also true that structural problems have gotten worse: To put it into terms of the picture in figure 1, the unemployment/vacancy relationship has shifted outward, so that at any given unemployment rate, there are more jobs vacant than there used to be.

As far as the causes of that, two things that people have focused on are the shift to different industries and the shift to different kinds of occupations. Something that has perhaps received less attention is the geographic shift in employment.

During the 1970's there has been very rapid growth in the Southwest and the Pacific States. There has been much less rapid growth in employment in the Northeast and some of the other areas of the country. I think that is another factor that lies behind the problems we're currently having.

Mr. **Bedell**. It seems to me another thing your study points out is that the difference in cyclical unemployment between 5 and 10 percent unemployment, is much more than a doubling of the cyclical unemployed. If I understood you correctly, you felt that 4-percent unemployed was really practically no structural unemployment, that there were roughly as many jobs open as there were unemployed. When we get to 10 percent, you have roughly 10 people looking for work for every job.

Ms. **Abraham**. Right.

Mr. **Bedell**. One of our witnesses yesterday said that if our GNP only grew at 2.3 percent, we could have 16 percent unemployed. That would mean a tremendous amount of cyclical unemployment based upon what you have seen happen. It would mean that we would still have a tremendous number of people for which there simply would not be jobs available, even if they could train or adapt to those jobs.

Ms. **Abraham**. I haven't calculated what an unemployment rate of 16 percent would imply about job availability. There might be 15 or 20 people per job.

Mr. **Bedell**. We certainly thank you very much for being here.

Ms. **Abraham**. Thank you very much, Mr. Chairman and Mr. Conte.

[Ms. Abraham's prepared statement follows:]

PREPARED STATEMENT OF KATHARINE G. ABRAHAM, ASSISTANT PROFESSOR, SLOAN SCHOOL OF MANAGEMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

President Reagan has commented on numerous occasions that his newspapers contain many pages of help wanted advertising. Implicit in these comments is the conclusion that something other than a shortage of employment opportunities is the main culprit in our current unemployment situation. Most reasonable observers will already have rejected this conclusion; my own research has convinced me that it is very far off the mark indeed. Careful examination of the best available evidence has lead me to the conclusion that, at the present time, the number of unemployed persons most likely exceeds the number of vacant jobs by a factor of ten or more. It is this evidence and its implications that I would like to discuss with you this morning.

Job Vacancy Data

To resolve the important question of how the number of available jobs compares with the number of persons seeking work, we need information on both unemployment and job vacancies. The monthly Current Population Survey reports, based on interviews with members of approximately 60,000 households concerning their labor force activities and other matters, provide us with excellent data on unemployment. There is unfortunately no ongoing survey of employers to provide us with comparable current data on job vacancies.

Indeed, we lack information on most aspects of employers' demand for labor. Until quite recently, information on hires, quits and layoffs in the manufacturing sector was collected monthly; the survey that provided even this relatively limited but still useful information was discontinued in December of 1981. It seems clear that better data on employers' labor market needs could considerably aid the policy making process. I would argue quite strongly that the Bureau of Labor Statistics ought to be given additional funding for the purpose of collecting such information.

While it is unfortunate that we currently operate no ongoing job vacancy survey, U.S. and Canadian employers have provided usable job vacancy data in connection with six pilot projects and longer-term survey efforts since the mid-1960's. These sources of data can be used to estimate the job vacancy rate associated with different unemployment rate levels and thus to make some statement about how the number of available jobs compares with the number of unemployed persons at the present time.

The six usable sources of job openings statistics cover the following time periods and areas: (1) for selected U.S. cities representing approximately 25 percent of the nation's total employment, we have vacancy data for each of three dates from late 1964 to April 1966; (2) nationwide job vacancy data covering the manufacturing sector are available for the period from April 1969 through December 1973; (3) comprehensive job vacancy data have been produced in Minnesota since January 1972; (4) comprehensive job vacancy data have been produced in Wisconsin since January 1976; (5) the recent Bureau of Labor Statistics job vacancy pilot program yielded 1979 and 1980 data covering four states; and (6) Canadian job vacancy data were generated from the start of 1971 through the end of 1978.

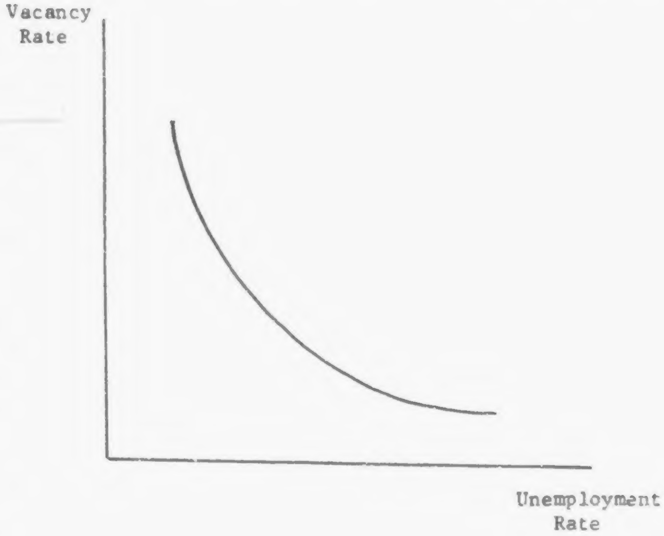
These sources of job vacancy data have received less attention than I believe they warrant. Perhaps the primary reason for this neglect is that the existing job vacancy data are widely believed to understate the true number of available positions. Some have argued that there were substantial numbers of "discouraged vacancies" (job openings that employers have given up recruiting to fill because they have been unable to locate suitable applicants) that the published job vacancy figures missed. Others have asserted that employers are often willing to hire well-qualified individuals off the street even when they have no specific openings. Still others have levied more technical criticisms against the extant job vacancy data, for example, arguing that the firms participating in the various surveys tended to have a below-average vacancy rate and that a more representative sampling of firms would have produced higher vacancy estimates. An important part of my research effort has been to pull together all of the relevant information bearing on these possible problems and on every other possible problem with the existing job vacancy numbers that I have heard mentioned. I then used this information to "correct" the published vacancy figures. Whenever there was a question about how important a particular source of potential understatement in the vacancy numbers was likely to be, I assumed that it was more important rather than less important in making my corrections. Furthermore, I made no effort to adjust the published figures downward to take account of possible sources of overstatement in the data. For both of these reasons, the corrected job vacancy numbers that I came up with are, if anything, almost certainly too large rather than too small.

As a check on the reasonableness of my corrected job vacancy numbers, I also performed some other calculations using a quite different approach. The job vacancy estimates derived via this alternative approach were reassuringly consistent with the estimates obtained using the approach I have described here.

The Unemployment/Vacancy Relationship

The corrected job vacancy data that I have described above apply, of course, only to the time periods and areas covered by the various job vacancy surveys. However, plotting the job vacancy rates obtained against unemployment rates for the same time periods and areas makes it clear that there is an inverse relationship between the job vacancy rate and the unemployment rate. When unemployment is low, employers tend to have many vacant jobs; when unemployment is high, employers tend to have few vacant jobs. The existence of such a relationship makes good theoretical sense. Figure 1 shows the general shape of the unemployment/vacancy relationship. If it can be assumed that the unemployment/vacancy relationship in the areas where vacancy data have been collected roughly mirrors the unemployment/vacancy relationship in the U.S. as a whole and if it can be determined whether and how this relationship has changed over time, my data can be used to support conclusions about how the number of jobs available today compares to the number of persons seeking work.

FIGURE 1. The Unemployment/Vacancy Relationship



The Number of Available Jobs

Straightforward calculations based on my vacancy and unemployment data suggest that during the last half of the 1960's, when the unemployment rate hovered within the 3.5 percent to 4.0 percent range, the number of job openings probably came close to equalling the number of unemployed persons. Between 1970 and 1980, a period that included three recessions and produced an average unemployment rate above 6.0 percent, there were probably an average of four or five unemployed persons per vacant job.

As of April of this year, the unemployment rate stood at 10.1 percent. Over 11 million people were without work and seeking a job. My calculations suggest that the number of unemployed people currently exceeds the number of available jobs by more than a factor of ten. This conclusion holds even after an adjustment is made to the figures to take account of the fact that the unemployment/vacancy tradeoff may have worsened (in terms of Figure 1, shifted to the northeast) over the past ten years. That is to say, my estimates indicate that U.S. employers are currently in a position where they would like to hire only about 1 million additional workers, at the same time that there are more than 11 million people unemployed. Even if every available vacant job could be filled instantaneously by an unemployed person, we would have achieved only a relatively small reduction in our unemployment count.

It should be remembered that the job vacancy numbers upon which this conclusion is based were very generously adjusted upwards to take account of possible downward bias. Let me also note that the official unemployment rate figures exclude large numbers of people who should arguably be counted. If the current official unemployment rate were adjusted to reflect a part time/full time distinction in both hours worked and hours desired and to reflect the number of "discouraged workers" (persons who would like to work but have given up looking), it would be almost 50 percent larger. Thus, I may have overstated the number of vacant jobs and understated the number of persons needing work. This means that there may well be more than ten people available to fill every vacant job.

Conclusions

My finding that the number of unemployed persons far exceeds the number of available jobs has extremely important policy implications. I would not like to argue against increased investment in well-designed training programs or against other measures designed to improve the matching of unemployed workers to available job openings. Such expenditure may well be appropriate. However, the evidence I have presented does indicate that, on their own, these measures can have little impact on the overall unemployment rate. Whatever policy package is adopted, it is imperative to remember that large reductions in the aggregate unemployment rate will require the creation of substantial numbers of new jobs.

Mr. BEDELL. Our next witness is Prof. Amitai Etzioni. It's my pleasure to know Mr. Etzioni, and we appreciate you being here, Professor. We're anxious to hear your testimony.

TESTIMONY OF AMITAI ETZIONI, PROFESSOR, GEORGE WASHINGTON UNIVERSITY

Mr. ETZIONI. Thank you, Mr. Chairman. Thank you. Congressman Conte, gentlemen, with your permission, I'd like to submit my statement for the record, and just highlight some of its main points.

Mr. BEDELL. We really encourage you to do so, and it will be made part of the record.

Mr. ETZIONI. Thank you. My main argument is that we suffer, on top of all the other problems which inflict our economy and our society, from a tendency to oversimplify matters, and rely on hype which substitutes for thinking. In part, it's created because we have a big townhall meeting, known as the electronic village, in which most things have to be summarized in the evening news in 1 minute and 10 seconds, even better if you can write it on a bumper sticker. One of the most recent slogans which substitutes for our serious thinking is the notion that we're going to close down the basic industries, and become a high technology society.

Most recently John Naisbitt's book has popularized that view, if it needed more popularizing. But first of all, there never was in modern economic history a society which did basically one thing. In Switzerland they tried to do that for a while, and just earn a living by making watches. Then Americans came with the digital watches, and Switzerland had a big problem.

In effect, the record shows that societies much smaller than ours, much simpler than ours, by a factor of 10 and 20, in order to survive have to adapt to change in circumstances, in order to accommodate the variety of people and skills they have to maintain a large variety of works, businesses, and pursuits.

Indeed, if you look beyond the headlines at the most reliable data available on the subject by the Bureau of Labor Statistics you see two things.

Talking about the next 10 to 15 years, I don't hold for those who claim they can predict much beyond that. We talk about a very slow shift of the order of magnitude of a three-quarter of 1 percentage a year in the composition of the labor force.

Now, a three-quarter percent shift is important for the human being involved, and the hundreds of thousands of jobs involved. But there is a world of difference between three-quarters of 1 percent a year, which amounts to 6 or 7 percent over a decade, and that notion we have of closing an industry, or line of industry, a whole sector, and shifting most everybody to high technology.

Another reason we come into this confusion is because we confused percentages calculated on a base as distinct for the actual number of jobs.

Let me explain this point, if I may. People talk about the fact that there are 50,000 jobs in computers, and they're going to go to 100,000, or a 100 percent increase in the number of jobs available in computers.

We talk about the fact that we have 3 million secretaries, and we shall need another 600,000, as a 20-percent increase. Therefore, the headlines capture there's going to be 100-percent increase in computers, and only 20-percent increase in secretaries. But there are going to be 600,000 secretarial jobs and 50,000 computer jobs. Indeed, the category most likely to go over the next 10 years is the unglamorous nonheadline grabbing janitors and sextons.

The State of Massachusetts, which has often had adopted as an example for high-tech State, has 9 percent of its jobs in high-tech. And that is, first of all, in the simple State of simple prediction, where the jobs are going to be. There are going to be many more jobs in health than in computer programing in the next 10 years, or next 20 years, by all predictions.

Now, another question is our relative advantage compared to other countries.

Peter Drucker, and others have argued, that we should let the basic industries go to Taiwan and Korea, and to the countries with cheap labor, and we will concentrate on doing high-tech. Behind this there's an assumption that somehow God divided the world into people who have a title to high technology, and the others who do the blue collar work. But that's not quite the way it works. Japan, West Germany, France, Britain, Israel, Austria—and I could name a few others—all want to be and are in a high-tech business. To our dismay, we just learn but we have to face the fact that Atari, the symbol of high-tech in some circles, closed some of its plants in California and moved to Asia, because it turns out we have no monopoly, or even special reason to believe that we necessarily do better in high technology than in other works.

Indeed if you look where we have comparative advantage, it includes for instance coal. Right at the moment this is not (at the depths of a recession in oil glut) very much on our mind. But there is no doubt that if the world economy will go again at a reasonable rate, and if we keep running down and deplete the oil reserves, there will come a point—it's difficult to predict exactly when—we will have to turn to coal. Unfortunately the other source of energy, as much as I like it personally, is solar, and it is not going to provide in the short run, and in the medium run, a major replacement for oil. Coal is a grubby, dirty, blue collar, non-high-tech business, basically.

The next point is that things have to be transported, and despite all the recent science fiction, I'd like to be on the record as stating, that whatever happens in the next 10 or 15 years, we will not transport grain from Iowa, or coal on laser beams, or on satellites. We'll continue to need things such as railroads, or trucking, again not a high-tech business.

I could spend the rest of my time just listing the important facts. We will continue to have a mix of pursuits, a mix of businesses, in short, a multitrack society. I'm not ignoring the fact that there will be some shift, and there ought to be some shift, into the high-tech industries.

It will be roughly of the magnitude three-quarter of 1 percent a year, which is not small. And I think programs should be there to take into account that shift.

The only thing I'm warning against is that simplification of having the picture of an closing down certain industries, and do largely one kind of business, computers, and biotech.

Finally, I'd like to call attention to the fact that aside from the general macropolicies, I'd much rather put interest rates down by 3 percent, than anything else. Given the option, if I had to do only one thing, reducing the interest rate by 3 percent would do more for everything we're talking about, than all the other problems combined. The others should come on top of it, of course, but not instead.

But we also need to tie our macro and microeconomic policies to our trade policy. Otherwise, we'll be thrown by our competitors from one end of this thing into another, according to what they target at the moment.

Let me just close on one example: One of our best and most successful industries, which is neither high nor low-tech, it's middle-tech, is the manufacture of major airplanes. I'm not talking about the small ones like Cessna, but I'm talking about Boeing. It's very important for us because we're very good at that, and it's a very important part of our national security. This is one industry the Japanese are trying to knock out of the market over the next 10 years, and they've been spending an increasing amount of billions in that direction.

What should be learned by this is we're paying for their defense, very largely. So they're undermining one of our major defense industries, while we're paying for their defense.

In the longer run, it's inconceivable to have competition where we keep handicapping ourselves, and at the same time pretending that we're part of a free trade game. We don't play by those rules, the other sides don't play by those rules, and until the ideal world of free trade will be achieved, and I pray for it like everybody else, they have to recognize the fact that there will be a managed international division of labor, rather than one nature will take care of.

In that process I would very much think we should sit down with Japan and say, "Look, either each one pays for their own defense, let's say. 7 percent of GNP each, or you not only will not undermine our military industry, but you'll help underwrite it. Then we can have free trade."

But short of that being the case, we have to put together measures to protect our industries for the period of rehabilitation, reindustrialization, restructure, until they're able to compete on their own feet, and not try to keep adjusting so retraining and unemployment problems, to whatever our competitors happen to target in a particular year. Thank you, Mr. Chairman.

Mr. BEDELL. Thank you, Mr. Etzioni. You have hit on something that impinges upon this study we're trying to make, and that is the international situation, and the ability of the U.S. to compete in world markets, including our own here in the U.S., and how that may affect our employment. Were you the one who told me that the Japanese had bought Rolls-Royce in England?

Mr. ETZIONI. No, but I'm sure it's true.

Mr. BEDELL. Somebody told me that, and they're expecting to improve those aircraft engines to where they will be competing with General Electric, isn't it?

Mr. ETZIONI. Yes.

Mr. BEDELL. That builds them here? We were going to see much more competition than we have seen in the past. In that regard, it may fit into what you're talking about with regard to the total aircraft industry.

One of the questions we have asked is whether or not the U.S. firms are going to automate sufficiently and rapidly to remain competitive with the Japanese, Germans, and others as well. Do you think they will?

Mr. ETZIONI. Well, at the moment it doesn't look like it. We have at the moment excess capacity in robotics, rather than people lining up to buy those we make or import.

The problem is that they are rather expensive in capital outlay, and that we have become somewhat like an underdeveloped country. We have a surplus of labor, and shortage of capital. We used to associate such situations with India, and Panama, and we used to scoff at the Indians when they used to build steel mills with hand baskets. We said they'd never heard about a crane, or a tractor.

But for the Indian economy, the logic was, hands were inexpensive and abundant, and there was a social purpose in putting them to work while the machines were expensive. We face a similar problem now.

What high interest rates mean is that capital is expensive, when a corporation faces the notion of throwing out its old assembly line and replacing it. By the way, parenthetically, there's very good evidence to show that if you want to get the benefits of those computerized machines—that's all they are—it's not good to replace one element; you have to convert the whole system; then you get your real benefit.

It's an extremely expensive proposition. So, given the shortage of markets because of the continuous slow and sluggish national and international economy, and the continued uncertain future of markets, corporations, on an average, are not quite rational, not logical, to make major capital outlays.

We have seen in the last 2 years—these are supposed to be the years of economic recovery—a cancellation of investment programs in robotics, and otherwise. And we have less of a capital outlay than we had before 1980. And so unless this turns around, unless capital becomes more abundant, and less expensive, I don't see corporations being in the position, most of them, to make major outlays to renovating any area, including this one.

Mr. BEDELL. I have the impression that it's not particularly a shortage of capital at this time, as the cost of capital, and the various opportunities for investment of capital where it may make more sense for United States Steel to buy oil companies, than it does to modernize their steel plants. Is my thinking incorrect in that?

Mr. ETZIONI. Yes, it's absolutely true. A shortage is reflected in the high cost. When something is abundant, the cost comes down, and something is short, the costs go up. So there's a close connection. Shortage doesn't mean it's not available at all. So the high cost of capital is the factor.

There are other investment opportunities which are more attractive. Again, unless we want to nationalize the economy, or start having what I would personally prefer, but I think it's politically unacceptable, is managed credit. Then we'll face the fact that as long as a free economy, when United States Steel has money, it goes and buys what makes more sense in the free market.

Now the reason they could buy oil was we had a recession, because then you could buy the stocks of the company, and in that way get control of assets at lower costs than building them. Recently we have many fewer of those mergers. It's not because of everything being brought out, it was the stock market being up. You no longer can play that game.

So I'm not as worried as some of my colleagues are about this merger binge. It was largely a symptom of a depth of the recession, and largely decline, once you return to a normal economy.

Mr. BEDELL. If, indeed, we do not remain competitive in world markets, and if indeed what we see is movements in two directions, one is more and more loss of world markets to foreign competitors. Secondarily, more and more of a movement of manufacturers a way to get cheap labor simply because they have not automated in that direction. Would that significantly impact upon your projection that they're not going to see much of a change in the labor requirement? Do you believe that what you say would be true, regardless of whether that happens?

Mr. ETZIONI. It could move over an eighth of a percentage, but not much more. One has to remember that these high-tech industries are not labor intensive.

Mr. BEDELL. We're not talking about high-tech industries now, I don't think. We're talking about whether we're going to be competitive.

Mr. ETZIONI. Oh, I see, generally.

Mr. BEDELL. In other types of manufacture, or whether we're going to become uncompetitive and move more of our work overseas to where there's cheap labor, because we have not automated.

Mr. ETZIONI. I'm sorry; I misunderstood the question.

Yes, though I would expect under those circumstances we will grow either more protective, we at least will not become very depending on export. We are now up to 12 percent, but we used to be only a 4 percent export society. What people keep throwing at us and saying is to be a trade war, everybody is going to suffer. That's true, but we will suffer less than most.

So unless the other countries will be more accommodating to open the market at their farm products, because we are very good. We are very competetive in farming, as I know you know. We keep having this notion that we cannot hack it, and definitely losing. I don't think that's the complete picture. One reason we don't hack it is because they play by two sets of rules.

For instance, we have a tremendous advantage, like importing farm products from Japan, and they don't let us do it.

Let me just give one example of how extreme it is. A few months ago the Japanese Prime Minister was here, and he reduced the tariffs on the importation of tobacco and cigarettes to Japan. And 3 weeks after he returned home, they increased the prices, by the same amount, by the way.

How can he do that? Because Japanese tobacco and cigarettes are handled by Government monopoly completely. So, he reduced the tariffs and he increased the taxes and prices on the cigarettes, and we cannot sell an additional cigarette in Japan; they're 40 percent above local prices.

Now, when they do that to our farm products, and we open the door to their VCR's without limitations, then you see that it's not just a question of competence, though of course it is a factor. So I think what will happen if this squeeze is more, we will find the political will to engage them on that level and win.

Mr. **Bedell**. One of your statements was that you expected us to use considerably more janitors?

Mr. **Etzioni**. Yes.

Mr. **Bedell**. How do you arrive at that projection? Where do you get your figures?

Mr. **Etzioni**. The Bureau of Labor Statistics.

Mr. **Bedell**. Do you have a question?

Mr. **Fithian**. I have just one question, Professor.

Professor Reich of Harvard argues that we should go into that segment of manufacturing where the highest value added segment, or proportion of labor can be used. We seem at this point to have a surplus of relatively expensive labor—auto workers, steel workers, and the like. What comparative advantages do you see for the United States if we go that direction, particularly in light of the ability of the multinationals to simply shift the manufacturing process to wherever labor is cheaper?

Mr. **Etzioni**. I join most of my colleagues who disagree with Professor Reich, that you can tell where there is a high value added. He sometimes implies that industries come with a little sticker attached to their smokestacks which says, "Here's high value," and some other ones say, "Here's low value."

You cannot tell by the future especially because what's high value today may not be high value tomorrow. You cannot adjust overnight.

There's an extremely difficult, if not impossible, task. Just to give one example: One of our most successful industries at the moment is personal computers. Well, 2 years ago, I'm not talking about 5 and 10 years ago, this was not expected so I'd like to hear much more from him how you predict where the high value added is going to be, and I am worried about us adjusting to the latest fad, only to find out that by the time we shifted people around, that fad has gone and blown over.

Now, to the high cost of labor I think there is a different issue. I'd just like to separate the two. We began a process from U.S. Steel to Eastern Airlines, where I don't enjoy it, and I don't celebrate it, but I think it's terribly necessary. There are unions, and nonunionized workers participating in major givebacks from fringe benefits to salaries because they are one reason we outpriced ourselves in the international market.

I'm afraid to say it, but the fact is that more will have to happen in that direction. We will not be able to afford increases in wages and salaries, not only not being able to match past wages, especially in expensive labor, but in effect have to, get back some of those improvements.

Mr. **Bedell**. Mr. Ray, did you have any questions?

Mr. **Ray**. Mr. Chairman, I'm sorry to have gotten caught in another committee, but I really don't know enough about what he's been saying at this time to ask a question, but I hope to later. Thank you.

Mr. **Bedell**. We appreciate very much your being here, Mr. Etzioni. Thank you.

Mr. **Etzioni**. Thank you.

[Mr. Etzioni's prepared statement follows:]

PREPARED STATEMENT OF AMITAI ETZIONI, PROFESSOR, GEORGE WASHINGTON UNIVERSITY

It is technically wrong and politically unwise to suggest that the United States is transforming from an industrial society into an information (or knowledge) or high technology society. To put it briefly first, the statements about the suggested transformation vastly exaggerate trends which are taking place at a slow pace, and they disregard some significant countertrends resulting from the need to adapt to the new energy environment, to shore up the basic economic foundations (to "reindustrialize"), and several national security considerations.

The political implications--writing off the old constituencies, and hitching one's political wagon to the new stars--disregard that the traditional constituencies are, and will continue to be, core constituencies of the Democratic Party, constituencies which need--and deserve--to be represented by it.

The Post-Industrial Vision. The end of industrial society is widely predicted. One of the most common lines of argument runs as follows: We started as a farming society, soon transformed into an industrial one. We are now well into the next transformation, into the post-industrial society. Already, the manufacturing sector employs only one out of every five Americans; most work in services; and the most rapidly growing services are information-based. We move from manual labor and dealing with objects--to dealing with symbols and words.

The way this is typically hyped up in the media is reflected in a front page Wall Street Journal column under the title: "Information Remolds U.S. Economy" (February 23, 1981). It tells of "a trend as fundamental as any ever to have transformed the U.S. economy--the switch to an information economy from one based on manufacturing." Similarly, John Naisbitt of Yankelovich, Skelly, and White puts it flatly: "the post-industrial society is an information society." Peter F. Drucker feels that "America cannot maintain a manufacturing base resting on traditional manual work and workers" and hence predicts/suggests that the U.S. will/should "shift" its labor intensive elements to developing nations. Alvin Toffler made post-industrialism the Third Wave, to sweep all in its wake.

Professor F.M. Esfandiary, author of Telespheres, writing in Los Angeles, reflects well the oversell of the post-industrial thesis. He reports that "powerful forces are revolutionizing life on this planet," that "we are leaping far beyond the context of industrialism;" that "in the age of international telecommunications 'far' and 'near' have no meaning." For anyone who feels these statements are not overdone, maybe his 1980 conclusion will do: "we are going through a time of spectacular growth."

Building on this view of historical trends it is further suggested that the U.S. develop an industrial policy to distinguish between industries which are deemed to be future-oriented ("winners") and others, found to be mired in the past ("losers"). The winners are to be endowed with public support (tax benefits, credits, etc.) to be denied to the losers. While different lists of potential winners and losers have been drawn up, the knowledge industry (especially computers) ranks high, if not at the top of most winner lists, and basic manufacturing industries are often placed among the losers.

The Actual Pace of Change. It should first be noted that changes in the sectors of the economy do take place, but at a very slow pace--less than one percent a year. Far from closing down a sector--and opening new ones--a marginal and very gradual shift of resources takes place. For instance, over 20 years (1959-1979), manufacturing in the U.S. declined from 24.1 percent of the labor force to 20.6 percent, or an average annual decline of 0.175 percent, less than one fifth of one percentage point.

The manufacturing sector is expected to further decline by another 1.4 percent by 1990 (compared to 1979)--over 11 years. Services have increased more substantially: between 1959 and 1979, their share of the labor force grew at an average annual rate of 0.3 percent, and they are expected to rise some more--2.4 percent over 11 years (1990 vs. 1979). While it is true that each percentage point represents many thousands of people, the basic picture is not one of closing down of one business and opening of a new one--"the way cars replaced horses and buggies"--but a very gradual change in the total business mix.

It follows that while it might well be worthwhile to invest, encourage, and promote rising, "with it," industries, it is neither practical nor desirable to ignore the older ones. They will be with us into the 1990s as important sources of employment, production, and export. After all, even agriculture is still a very important U.S. sector that no sensible person would wish to close out. In 1980, for example, the U.S. exported $41.3 billion in agricultural products, accounting for 19 percent of all U.S. exports.

It should also be noted that part of the projected shift is the result of statistical redefinition, not economic transformation. Thus "printing and publishing" has been redefined as information, rather than the way it used to be--manufacturing. Computers are defined as a knowledge industry par excellence, although the hardware (as distinct from the software) is increasingly a matter of routine manufacturing. The new rising robotics industry is the product of new knowledge but the "arms" and "legs" and bodies of the robots, are not made out of symbols but cranes, metal beams, and such.

Important Countertrends and "Counter"-Considerations. The post-industrial thesis draws on a tri-sector view of the economy. Accordingly, the primary sector is agriculture and mining; the secondary--manufacturing; and the tertiary, services. (More recently a distinction has been drawn within services, between regular services and knowledge-based ones.)

The primary sector is expected to shrink first and most, the manufacturing is the next "to go," while the service sector is to be on the rapid uptake. The fact, though, is that the changed energy conditions and the neglect of the economy's infrastructure both require and are achieving a rededication of resources, not only to the secondary (manufacturing) sector, but also to the primary sector, especially mining. It is already a growing sector and one expected to be larger in 1990 than it was in 1979. The same holds for construction.

Above all, while the knowledge sector grows--the shoring up of the economy requires attention to basic sectors that have been neglected and are not about to be replaced by knowledge industries. The rise of communications tools will not replace the need for an efficient transportation system. The notion that people will use picture-phones, conference calls, and data-phones instead of travel is highly simplistic. If such technologies were to replace 25 percent of travel by 1990, they would have captured much more of the sector than any reasonable projection allows. More to the point, travelling by people is less central to modern economic transportation than that of raw material, semi-finished goods, and products. Coal, grain, and steel will not be communicated over telephone lines or by satellites. They will require modernized ports, rails, or other object-carrying facilities (trucks, slurries, barges). As this sector has particularly deteriorated, it would be very unwise not to rehabilitate it--for the future. Goods in transportation are akin to goods in inventory; they add to the costs, and pull down productivity. Furthermore, the less efficient transportation, the less integrated the economy, and the lower the benefits of economies of scale.

Similarly, energy is not, by and large, a knowledge-based industry. We need to sink more and deeper and different oil wells, mine more coal, mass produce and install passive solar units, and probably build more nuclear plants. All these industries have technical elements--but they are basically object-industries and blue-collar jobs. Much the same must be said about the work generated by energy conservation.

Within defense, the "industry" most likely to grow in the near future, the largest amount of resources is clearly committed--to hardware. There is an important electronic/ knowledge component, and it is rising, but battleships, tanks and missiles are largely the product of "basic" industries. Moreover, it is already widely held that too much investment is made in these military systems, making them too complicated and costly, and the newest trend is to seek large production of simple items, the manufacturing of guns, grenades, etc. Also, the defense mix should be changed to provide more for foot soldiers, the "blue collar" of the defense sector, and reduce the reliance on nuclear forces.

International Division of Labor. The notion that the U.S. should "export" low-skill jobs to third-world countries and concentrate on high-skill ones is similarly a combination of a partial fine insight with a dangerous overstatement. It is true that in an abstract world, in which each country devotes itself to producing whatever its "comparative advantage" prescribes, and to exchange its products with others in an uninhibited free trade--all would benefit. But the reality of international relations is one of OPEC, Soviet and Chinese blocs, and hidden and not so hidden, deliberate and unwitting protectionism in Japan and Europe, and elsewhere. To follow in this context a simple-minded dedication to two economists' abstractions (comparative advantage and uninhibited trade) would have disastrous consequences for our less-skilled workers, whose numbers are being increased by massive immigration.

The notion that we can take our less-skilled workers and train all or most of them to work in high-skill jobs is all too optimistic. We should invest more in schools, training, retraining, and improved tools for matching people with jobs. But we should not delude ourselves that we shall be without a sizeable low-skill segment of the labor force in the foreseeable future. And they will need jobs, or they will swell the social costs very considerably.

Nor is it clear at all that if we were to "export" our low-skill jobs, we would not face other countries better suited to do high-skill jobs. Then, the U.S. might be found "most suited" to produce Coca-Cola, hot dogs, short-order cooks, and little else. Also, services tend not to generate much of a chain reaction, in the sense that once you have served a hamburger, that does not create nearly as much additional work as building a car. Clearly, the criteria of comparative advantage and free trade must be mitigated by common sense, considerations of national security, social sensitivity, and demand for mutuality in international trade concessions.

Politically, there are major Democratic constituencies in the basic industries (auto and steel workers, for example), and minorities and less affluent whites (who often command lower skills and are less educated than the knowledge sector requires). To write them--and their jobs--off, and to go after the college-educated, is not a route to a broad-based political party.

* In conclusion, we have been for a long time, and we will continue to be--a two-track society, with strong elements in both basic industries and high technology ones. The basic industries need to be retooled and may be trimmed; the new ones encouraged, but not one at the expense of the other. Fortunately, the two industries have different needs; the older ones require more infusion of capital, the newer ones--are shorter in human resources. Hence promoting one need not come directly at the cost of the other. Both provide vital foundations for America, at least for the next decades.

Mr. BEDELL. Our next witness is Ms. Leslie Loble who is with the Communications Workers of America. We appreciate very much your being here and for your patience.

Ms. LOBLE. No problem. I have with me Mike Dymmel who is our resident expert in training programs at the Communications Workers of America. I will be reviewing one of them later, and if you have any questions, Mike can answer them.

I, too, like the other witnesses have a written statement. I would like to submit it for the record and I will try to be brief in my summary.

Mr. BEDELL. Very good. I would appreciate that very much.

TESTIMONY OF LESLIE LOBLE, LEGISLATIVE REPRESENTATIVE, COMMUNICATIONS WORKERS OF AMERICA; ACCOMPANIED BY MIKE DYMMEL, EXPERT IN TRAINING PROGRAMS, CWA

Ms. LOBLE. It is pretty clear, as we have heard testimony already this morning and you heard yesterday too that we are on the verge of a new economic era that deals with information and data and word processing much more than just production of an actual product. The members of CWA are experiencing this change firsthand. A day hardly goes by without some new technology being introduced into their working lives. The telecommunications industry, in which most of our members are employed, is therefore both leading and exhibiting the technological revolution. Our whole concept of telephone service, for example, is becoming rapidly outmoded. When you and I call home for dinner, which is what we think of as telephone service, it really is quite an old-fashioned idea. Each day it becomes a smaller and smaller part of telecommunications. Today, communications is computer to computer. Information isn't transferred by voice; it is essentially transferred by the beeps and buzzes of machines.

This is an exciting and very stimulating phenomenon. New technology can provide many benefits to our Nation: Lower costs and improved productivity could boost our lagging economy; standards of living can improve allowing us to enjoy more and better products.

Technology can bring us everything from timesaving household gadgets to lifesaving medical devices. In the workplace, developments in technology can improve working conditions and open up new jobs.

Perhaps not quite so clear as the benefits are the possible costs of technological change. The dynamism is both exciting and a little frightening. There are huge numbers of our population who cannot begin to comprehend the impact of high technology in part because the inventors of the high technology have not even figured out how to apply it yet.

American workers, including CWA members of course are not just a little disconcerted by the new technology. They also see immediately the negative and often devastating effects it has on their quality of work life.

I would like to review some of the consequences of new technology.

A common assumption about new technology is that it will upgrade the skill requirements of existing jobs.

To a certain extent, it is true that new skills will be required, but sophisticated equipment like computers so far has proven also to have the opposite effect. Essentially it downgrades skills. We have heard a lot of statistics but maybe some anecdotes could shed some light on this effect.

It was easy 10 years ago, it was easy to find an inside plant technician in the Bell System who was familiar with all the equipment and was capable of both diagnosing problems and making repairs. Because of new technology, however, many technicians are not involved anymore with hands-on experience. Instead, the problems are identified on a highly automated test desk which directs the worker to replace the faulty piece of equipment and it is usually sort of a snap-in, snap-out process that requires very little skill.

A related consequence of new technology is the transfer of highly skilled and better compensated jobs to management employees. Rank and file workers who make up the majority of the American work force therefore lose the opportunity for future employment. They are losing out on all the benefits of the high-tech era. A few statistics bear this out as Mr. Etzioni related them to you. Three of the fastest growing occupations by 1990 are high tech in nature, but in terms of the number of jobs, American workers can look forward to becoming a janitor or a fast food worker or kitchen helper, et cetera.

The consequences for the skilled union member is that his or her job is continually downgraded as new technology is used until he or she becomes a virtual automaton. But at the same time, however, the challenging, skillful jobs are being shifted more and more to management employees. The opportunities of the 21st century thus will be reserved for those already advantaged.

Meanwhile, the backbone of America's work force sweeps up the paper refuse of high tech or serves the systems analyst his or her lunch.

New technology also increases the size and centralization of management control. Decisions that were once made by the individual worker now are made by managers several levels removed or by a computer which is programed to monitor and command.

The telephone operator's experience is a good example. The modern operator is continually paced and timed by a computer. She can't take more than seconds to answer a service call. She cannot spend too long at her machine-programed break or else the machine and then management will come down on her.

The consequence for the worker is that she or he suffers a great deal of stress. The consequence for the consumer is that she or he loses human and responsive and adequate service.

A fourth effect of new technology is the replacement of vast numbers of workers.

The automobile industry's experience with this has gotten a good deal of attention but unfortunately it is not unique. There appears a widespread belief that emulating the Japanese model, including using robots to produce, will bring automatic success to the American car business. Certainly there may be productivity increases and management loves to remind us that robots can't strike, as if that is the sole cause of the American car industry's trouble.

But the truism that robots cannot buy cars, telephones, or clothing shouldn't be taken lightly. The introduction of new technology which replaces workers creates tremendous economic problems: unemployment, excess supply, and underutilization of capacity, in short, conditions much like today's recession. This raises what I think is a really essential policy question: Are the productivity increases really worth it if the American economy as a whole suffers.

As new technology reduces the skills required of workers and lowers demands for workers in general, pay levels begin to fall. The position of central office technician in the Bell System, formerly a top craft job, 4 years ago was changed dramatically by the introduction of computerized testing equipment. Management consequently proposed lowering the pay level to 60 percent of top craft compensation. After extensive bargaining, we got the final level of 80 percent of top craft.

The consequence for some 6,000 CWA members is that now they are earning far less than 4 years ago and it is a direct result of new technology. To help combat the problems of technological change, CWA has implemented a number of what we consider rather innovative programs. One such program, which is supported by our national training fund which will receive formal accreditation this month, authorizes the establishment of training centers in such communities as Indianapolis, Phoenix, Los Angeles, and Denver.

These centers provide training for a wide range of skills from electronics to computer use and programming to human relations and marketing. The training needs are determined by the union locals participating in the centers, usually in close cooperation with area employers having CWA-represented workers. Our chief criterion for determining skill requirements is employment security. We therefore take into account the expected direction not only of the employer company but of the industry as a whole. We hope the training programs will allow CWA members to better meet the challenges of the high-tech world. Instead of watching technologically skillful jobs go more and more to managerial employees, our members will have the skills needed to compete. Our employers also benefit; they get a highly skilled worker that is immediately productive at minimal employer expense.

Our second program is the technology change committee. Our experience with technological change in telecommunications has shown that the unilateral introduction by management of new equipment is one of the most important underlying causes of the problems with technology. New systems are brought on line with little or no concern for the human impact. Consequently, productivity falls, virtually canceling out any benefits provided by sophisticated machinery. The only way to counteract this effect is to provide for effective worker involvement in all aspects of the technological process from inception to implementation and eventually to replacement.

The purpose of our technology change committee, which by the way is in each of the Bell System operating companies, Western Electric and Long Lines, is to foster a truly cooperative relationship between labor and management vis-a-vis technology. For example, one of the requirements is that management provide us with at least 6 months notice of a major technological change. This gives both AT&T and CWA the opportunity to analyze these changes, assess their impact, and perhaps recommend alternative means of implementation.

The approach in turn will reduce the hostility and apprehension caused by arbitrary introduction of new equipment. If there is less hostility, then there is greater efficiency adapting to a new routine, with the associated effect, of course, on productivity and service.

Our third program is the joint national CWA-AT&T quality of work life committee. The genesis of this quality of work life committee was a 1980 study which showed that job pressures caused by oversupervision and technological change could be reduced through increased participation. In essence, we saw that the controlling approach to management was counterproductive. In the long run human values support economic ones. All the evidence shows that workers are highly productive if and when they are treated fairly and given the chance to contribute fully to their work.

Unfortunately, managers don't always see this. They tend to focus more on the short run and—there is no denying this—you can always get more immediate production out of a worker by pushing him or her and increasing control.

The cost, though, of worker dissatisfaction often shows up later when that individual manager has moved on.

Finally, our fourth way of dealing with the effects of technology is the joint occupational job evaluation committee. Despite our initial skepticism about job evaluation, we entered into this project because of a need to make sure that our members were being properly compensated for their work.

Technology has drastically changed jobs around the country. A job evaluation plan will help us identify and adjust compensation where new technology has rendered traditional wage relationships meaningless. Only with union involvement can we be assured that our members are being paid for the increased skill, responsibility, and adverse working conditions that result from the new technology.

I would like to focus a little bit on the public policy implications of all of this. Technological change is already being dealt with by public policy and in fact a wide range of recent decisions are actually fueling and pushing the technological revolution.

If you look at the Reagan tax bill, for example, there are tremendous tax cuts for businesses. They actually get a return from the Federal Government for investing in things like computers and data processing equipment. Similarly, in our Federal budget decisions, you see that we have had large increases in R&D financing, for example. But at the same time, the Federal budget has cut programs which benefit middle or lower income workers far more than R&D or corporate tax breaks.

Those programs, like employment training and retraining, vocational education and basic education, all have been slashed over the past few years. Even the Reagan proposal to tax fringe benefits has a negative effect on the majority of American employees because it hits at something like employer-supported tuition aid which would give people the opportunity to learn new skills.

Congress therefore must approach technological change in a sober, careful manner. We fear that we are in danger of rushing into this new economic era armed only with scanty and even questionable statistics and very optimistic dreams, enacting policies and programs that not only are haphazard, but which only may exacerbate the problem rather than improve it.

A lot can be done in the private sector and the CWA programs are just a few examples. But the Government must get into the act. Everything from taxes to spending to trade and labor laws should and must be considered.

New technology opens up a world of opportunity and we all stand to benefit. But clearly there is a downside. If we are not careful only a few will gain. For American workers, new technology seriously could mean continuing low-skilled, low-paying jobs, or even for many permanent unemployment.

I would like to stress that our cautious approach to this is not an attempt to throw sand in the wheels of progress. We in fact believe that only through a cooperative and careful approach to implementing new technology can the economy reap its benefit.

In closing, I would like to share with you a sentiment of one of our employees. Ian Ross of Bell Laboratories recently said:

> We are being led by the technology of the moment and I think that we should never lose sight of the fact that technology should be serving people and not people serving technology.

We concur wholeheartedly with this sentiment and we are working to insure it becomes a reality. Thank you very much.

[Ms. Loble's prepared statement follows:]

PREPARED STATEMENT OF LESLIE LOBLE, LEGISLATIVE REPRESENTATIVE, COMMUNICATIONS WORKERS OF AMERICA

Mr. Chairman, Members of the Subcommittee: thank you for this opportunity to testify on the critical subject of technological change and its impact on American workers.

My name is Leslie Loble. I am a Legislative Representative of the Communications Workers of America (CWA) which represents some 675,000 workers in telecommunications, public service, cable TV, data transmission and technology production, among other fields. Most of our members are employed by AT&T and the Bell System.

Phrases like "high tech" and "technological change" are heard more and more frequently these days. Everyone from policy-makers to educators, from economists to stockbrokers are predicting huge benefits from the introduction of new technology. The high tech areas of our economy, including the communications and service sectors, are projected for explosive growth rates.

Evidently we are on the edge of a new economic era, what some call the Information Age. Just as we moved from an agriculturally-dominated economy to the industrial age, we are now in an "information revolution" which will take us into an economy where products are not produced so much as data is transmitted, processed and serviced.

The members of CWA are experiencing this change first hand. It often seems like a day doesn't go by without some new technology being introduced into their working lives. Bell Labs churns out inventions, Western Electric manufactures them, the local telephone companies install them, and our members use them.

The telecommunications industry, therefore, is both leading and exhibiting the technological revolution. Our whole concept of telephone service is fast becoming outmoded, for example. Telephone service--when you or I call home to check on dinner--is really quite old-fashioned; each day it becomes a smaller and smaller part of telecommunications. Today, communication is computer to computer. Information isn't transferred by voice, it's by the beeps and buzzes of machines.

Clearly this is an exciting, stimulating, wondrous phenomenon. New technology can provide many benefits to our nation. Lower costs and improved productivity can boost our lagging economy. Standards of living can improve, allowing us to enjoy more and better products and services. Technology can bring us everything from time-saving household gadgets to life-saving medical devices. In the workplace, developments in technology can improve working conditions and open up new jobs.

But not quite so clear are the possible costs of technological change. Just as this dynamism is tremendously exciting, so too is it somewhat frightening. Not only is the process of change itself a little scary, but also the technology itself. Huge numbers of our population cannot begin to comprehend the services provided by high tech, in part because the inventors don't even know how to apply it yet. And American workers, CWA members among them, are not just a little disconcerted by the new technology, they also see immediately the negative, often devastating effects it has on their quality of work life.

IMPACT OF TECHNOLOGICAL CHANGE ON WORKERS

Technological change clearly has both positive and negative effects. Our own experience with the Bell System shows that on the positive side of the ledger, new technology:

- Expands production
- Improves productivity
- Enhances compensation levels initially relative to job demands
- Eases layoffs
- Makes jobs easier

In the debit column, however, the emerging high tech world:

- Deskills jobs
- Denies employment security to rank and file workers
- Increases management control
- Reduces pay levels in the long run
- Replaces employees with machines
- Negates productivity increases by expanding supervisory personnel and by creating worker stress

The experience of the telephone operator is a good example. Fifteen years ago most operators used the old cordboard--the equipment on which calls came into the central office, were received by the operator, and then plugged into a circuit that carried them to their destination. Although that equipment is still used in some rural parts of our country, it generally has been replaced by the computerized TSPS (Traffic Service Position System). This system allows for the elimination of local phone offices, paces the flow of calls to the individual operator, catalogues the operator's average work time for each call, predicts the future flow of calls, and schedules the operator's breaks. In general, it welds the operator to the equipment. Combined with scripted responses that the operators are required to provide, this equipment removes all decision-making and human responses from the operator's job.

Workers are Deskilled

A common assumption about new technology is that it will upgrade the skill requirements of existing jobs. To a certain extent it's true that new skills will be needed. But sophisticated equipment like computers so far has proven also to have the opposite effect: a downgrading of skills.

As two Stanford University economists, Henry M. Levin and Russell W. Rumberger, point out, "The proliferation of high technology industries and their products is far more likely to reduce the skill requirements for jobs in the U.S. economy than to upgrade them."

The telephone operator, for example, needs far less knowledge today to handle a long-distance call than a decade ago. She or he isn't involved with the customer, doesn't handle billing, and merely monitors, rather than controls, the call placement process.

Similarly, ten years ago it was easy to find an inside plant technician who was familiar with all the equipment and capable of diagnosing problems and making the repairs. But because of new technology, many technicians no longer are involved with hands-on work. Instead the problems are identified on a highly automated test desk which directs the worker to replace the faulty piece of equipment, usually a snap-out-snap-in process requiring very little skill.

Loss of Opportunity

A related consequence of new technology is the transfer of highly skilled--and better compensated--jobs to management employees. Rank and file workers, who make up the majority of the American workforce, therefore lose the opportunity for future employment. They lose out on all the benefits of new technology.

A few statistics bear this out. Three of the fastest growing occupations are high-tech in nature. According to government figures these occupations will grow more than 100% by 1990.

But in terms of the number of jobs generated by 1990, American workers can look forward to becoming a janitor, cashier, fast food worker or kitchen helper. These occupations will provide three, four, five times as many jobs by 1990 as high tech work.

What happens to the skilled union member, given these projections? His or her job is continually downgraded as new technology is used, until he or she becomes a virtual automaton. At the same time, however, the challenging, skillful jobs of the high tech era are shifted more and more to management employees.

The opportunities of the 21st century thus will be reserved for those already advantaged--aided by public policy which, for example, stresses the higher education which not every future American worker will enjoy. Meanwhile, the backbone of America's workforce sweeps up the paper refuse of high tech, or serves the systems analyst his or her lunch.

Management Control Increases

New technology also increases the size and centralization of management control. Decisions once made by the individual worker now are made by managers several levels removed or by computers programmed to monitor and command.

The operator's experience again is illustrative. The modern-day operator is continually paced and timed by a computer. She musn't take more than seconds to complete a service call, or dawdle too long at her machine-scheduled bathroom break else the machine, and then higher management, will come down on her. The worker thus suffers a great deal of stress and the consumer loses human, and I might add, responsive, adequate service.

In the Bell System, we have seen this increasing management control virtually negate the positive effects of new technology. A recent study demonstrated that supervisory hours worked grew from 58.9 million hours per year in 1947 to 120.2 million hours in 1978. Telephone operators worked 402.1 million hours per year in 1947, but this plummeted to 177.1 million hours in 1978 because of the elimination of the operators' jobs by technology. Increased management control is exhibited by the fact in 1947, there were 12 operators for every supervisor, but by 1978 there were more supervisors than operators.

This technology-driven approach to management is called the systems approach. It generally exhibits rigid and inhuman logic--take the following statement by sociologist Robert Boguslaw to a group of systems engineers:

> "Our immediate concern is the exploitation of the operating unit approach to systems design no matter what materials are used. We must take care to prevent this discussion from degenerating into the single-sided analysis of the complex characteristics of one type of systems materials, namely human beings. What we need is an inventory of the manner in which human behavior can be controlled, and a description of some of the instruments which will help us achieve that control. If this provides us with sufficient handles on human materials so that we can think of them as metal parts, electrical power or chemical

> reactions, then we have succeeded in placing human material on the same footing as any other material and can begin to proceed with our problems of systems design. There are, however, many disadvantages in the use of these human operating units. They are somewhat fragile, they are frequently stupid, unreliable and limited in memory capacity. But beyond all this, they sometimes seek to design their own circuitry. This in a material is unforgivable, and any system utilizing them must devise appropriate safeguards." (emphasis added)

Employees are Replaced

A fourth effect of new technology is the replacement of vast numbers of workers. The CWA study cited earlier not only demonstrates increasing management control but also the steep decline in employment of rank and file workers. With machines doing the job there simply is no need to use humans.

The automobile industry's experience with this phenomenon has gotten a good deal of attention. There appears a widespread belief that emulating the Japanese model, including using robots to produce, will bring automatic success to the American car business.

Certainly, there may be productivity increases, and management loves to remind us that robots can't strike--as if that were the sole cause of the American auto industry's troubles. But the truism that robots can't buy cars--or telephones, or clothing--shouldn't be taken lightly.

The introduction of new technology which replaces workers creates tremendous economic problems--unemployment, excess supply, underutilized industrial capacity, etc. In short, conditions much like those of today's recession. This raises a critical question: are there productivity increases (which themselves are questionable given available data) really worth it if the American economy as a whole suffers?

Pay Levels Fall

As new technology reduces the skills required of workers, and lowers demand for workers in general, pay levels begin to decline.

The position of central office technician in the Bell System, formerly a top craft job, four years ago was changed dramatically by the introduction of computerized testing equipment. Management consequently proposed lowering the pay to 60% of the top craft compensation level. After extensive bargaining, the final pay level was set at 80% of top craft. Some 6,000 CWA members today are earning significantly less than they were four years ago, a direct result of new technology.

A recent study confirms the CWA experience. The manufacturing wage of a high tech worker pays 25 cents per hour less than the average manufacturing wage across Massachusetts.

When new technology initially is employed, compensation is more than adequate for the work required. But as that technology becomes more entrenched, and jobs are fractured into smaller and smaller components, there remains little justification for previous pay levels. Consequently, they quickly drop off, leaving those workers who still have jobs with a far lower standard of living.

CWA PROGRAMS

To help combat the problems of technological change, CWA has implemented a number of innovative programs.

National Training Fund

One such program, supported by our National Training Fund, which will receive formal accreditation in May, authorizes the establishment of training centers in such communities as Indianapolis, Phoenix, Los Angeles, and Denver. In fact, our Indianapolis facility officially opened its doors just last week.

These centers provide training for a wide range of skills, from electronics to computer use and programming to human relations and marketing. The training needs are determined by the union locals participating in the centers, usually in close cooperation with area employers having CWA-represented workers and with both CWA-employed and outside educational experts. Our chief criterion for determining skill requirements is employment security, and we therefore take into account the expected direction of the employer-company as well as of the industry as a whole.

The Indianapolis center, for example, has set up courses in such areas as computer literacy, computer technology for both users and technicians, computer programming, marketing and sales, and data transmission. Training participants will complete their courses with a facility in the theory, use and service of such sophisticated technology as fiber optics, micro-wave, and computer components from micro-chips to keyboards.

These training programs will allow CWA members to better meet the challenges of the high tech world. Instead of watching technologically-skillful jobs go more and more to the managerial employee, our members will have the skills needed to compete. Our employers also benefit--they get a highly skilled worker who can be immediately productive at minimal employer expense.

Technology Change Commmittees

CWA's experience with technological change in the telecommunications industry reveals that the unilateral introduction by management of new equipment constitutes a significant underlying cause of technology's negative effects. New systems are brought on line with little or no concern for the human impact. Consequently, productivity falls, virtually cancelling out any benefits provided by sophisticated machinery.

The only way to counteract this effect is to provide for effective worker involvement in all aspects of the technological process, from inception through implementation and, finally, replacement.

Our 1980 Bell System contract set up a Technology Change Committee in each of the Bell System Operating Companies, Western Electric and Long Lines. Each committee consists of as many as three Union and three Company representatives. The committees talk about employment and training for workers affected by technology and discuss possible applications of existing job protection programs.

The purpose of these committees is to foster a truly cooperative labor-management relationship vis-a-vis new technology. Such a relationship benefits both sides, as well as the consumer and the economy as a whole. Cooperation means peak productivity can be achieved more quickly with less stress for the worker.

By providing adequate advance notice of any major technological change (the 1980 contract requires a six-month notice), for example, both AT&T and CWA can analyze the changes, assess their impact and recommend alternative methods of implementation. This approach in turn will reduce the hostility and apprehension caused by arbitrary introduction of new equipment. And if there's less hostility, then there's greater efficiency in adapting to a new routine--with the associated effect on productivity and service.

Because the program is so new, it is too early to make any judgments of its effectiveness. But early reports are very encouraging. Right now, the committees are learning to work together to solve problems and build up confidence.

At present, we also are trying to build up a network through our stewards to channel information to the committee. We feel that this is the best way to harness the knowledge of the true experts on the effects of technological change: the workers. This approach not only increases participation by the workers, but also provides practical solutions to the problems new technology creates.

We hope that the committees will mature and expand their scope of responsibility. After the parties have learned to acknowledge and respect the concerns of the other, it may be time to introduce a "vertical slice" approach to the introduction of new technology. This would mean that a group of employees from all levels of the Company, down to the shop floor, would meet to decide how the technology would be introduced.

Quality of Work Life (QWL) Committees

The joint national CWA/AT&T Quality of Work Life (QWL) Committee set up by our 1980 contract also is developing a process to help our members deal with issues of job pressures and technological change at the workplace.

The genesis of this Quality of Work Life committee was a 1980 study which showed that job pressures caused by oversupervision and technological changes could be reduced through increased participation. And like the Technology Change Committees, a motivation for management should be to reduce job pressures so that efficiency and productivity improve. The motivation for the Union is to improve our members' working lives and protect their jobs, which in turn will allow them to give good service to consumers.

Initially, the national QWL committee reached agreement on a statement of principles comprising the framework for all worker participation activities within the Union at AT&T. In brief, these guidelines establish that:

- workers' rights are explicitly protected (e.g., no layoffs or speedups);
- the activities will not intrude on collective bargaining;
- there is an explicit commitment to human goals in addition to economic ones. We have no objection to increasing productivity--we want AT&T to be an efficient and profitable company. But the values of safety, dignity and human development at work should be equal in importance;
- the Union should be involved on an equal basis in all phases of the process, from planning to implementation; and
- all decisions about work changes should come primarily from discussions by the workers themselves.

After establishing these guidelines, both CWA and AT&T began to train and educate union and management leaders, respectively, about worker participation. We plan to move carefully on actual participation at the shop floor level. Once the local programs begin, they will be quite independent and work out their own way of approaching QWL process. But they cannot succeed if a strong climate of support has not been created at the higher levels first.

We believe that the controlling approach to management is counter-productive. In the long run, human values support economic ones. All the evidence shows that workers are highly productive if and when they are treated fairly and given the chance to contribute fully to their work. But managers don't always see it. They tend to focus more on the short run, and you can always get more immediate production out of workers by pushing them and increasing control. The costs of worker dissatisfaction thus often don't show up until the manager responsible has moved on to another position.

Given this, the Union's role in the QWL process is crucial: to stick consistently to the long-term goal, guided by the human values which we have always advocated. We see worker participation as a tremendous opportunity, as well as a challenge. The results will be a strengthened Union and hopefully all parties in the industry will benefit.

Job Evaluation

Finally, I will explain to you our fourth way of dealing with the effects of technology, the joint CWA/AT&T Occupational Job Evaluation Committee. This is a joint national committee of three union and three management representatives. It's charged with developing a job evaluation plan for the Bell System to construct a hierarchy of jobs acceptable to both parties.

Despite initial skepticism about job evaluation, CWA entered into this project because of a need to make sure our members were being properly compensated for their work. Technology has drastically changed jobs across the country. A job evaluation plan jointly developed and implemented by CWA will help us identify and adjust compensation where technology has rendered traditional wage relationships meaningless. Only with Union involvement can we be sure that our members are being paid for the increased skill, responsibility and adverse working conditions that result from technological change.

PUBLIC POLICY IMPLICATIONS

The issues surrounding the impact of technological change already are being treated by public policy. Indeed, a wide range of recent policy decisions actually are pushing technological change and thus contributing to some of the problems, as well as the benefits.

Take the Reagan tax bill, for example. Along with huge tax breaks for higher income individuals, the Reagan supply side tax cut also gave tremendous reductions to businesses. Some of these breaks created significant incentives to rapidly expand new technology. The new depreciation rules, for instance, allow businesses to actually get a return from the federal government by investing in computers, data processing equipment, etc.

Similarly, recent federal budget decisions are driving the technological revolution. In the past few years, we've seen large increases in funding for research and development. Higher education programs, particularly those aimed at high tech, have received a federal financial boost too.

But at the same time, the federal budget also has cut a number of programs which would benefit middle- and lower-income workers more than corporate tax breaks and R & D financing. Specifically, employment training and retraining have been slashed, along with vocational and basic education. Even the Reagan proposal to tax fringe benefits has a negative effect on the majority of American workers. Employer-supported tuition aid programs allow workers to obtain the skills needed in the future, and help employers retain a stable, educated workforce. Taxing these benefits eliminates such positive effects.

Congress therefore must approach technological change in a sober, careful manner. We are in danger of rushing forward into the Information Age armed with scanty statistics and optimistic dreams, enacting policies and programs that not only are haphazard, but which also may only exacerbate the problems of technological change.

The Subcommittee's hearings these past two days are a critical first step. Before we can deal with a problem, we must know what it is. Also, you aid the process by collecting examples of existing programs serving to ameliorate the negative side-effects of new technology.

A lot can be done in the private sector. The CWA programs outlined here are an example.

Yet government must get into the act, too. Everything from taxes to spending to labor laws must be considered.

I've already reviewed just a few existing laws which affect technological change. But there are other proposals which could vastly improve America's ability to lead and profit from the technological revolution. For example, there should be established rules to guarantee notice of new technology, to assess technological change through impact statements, to encourage joint labor-management implementation and decision-making in this crucial area, and to protect those hurt by technology fallout.

PROGRESS FOR ALL

New technology opens up a world of opportunity. America's economy can expand and improve with the advent of "high tech." All of us stand to benefit as we move into the Information Age.

But clearly there is a down side to new technology. If we are not careful, only the advantaged few will gain. For American workers this could mean low skilled, low paying jobs or even permanent unemployment.

CWA's cautious approach is not an attempt to throw sand in the wheels of progress. In fact, we believe that only through a careful and cooperative process of implementing new technology can the economy reap its benefits. Otherwise, employers, workers and consumers continually will work to protect a narrow self-interest to the detriment of all.

In closing, let me share with you a sentiment of one of our employers. Ian Ross of Bell Labs recently said that "We are being led by the technology of the moment, and I think that we should never lose sight of the fact that technology should be serving people, not people serving technology..."

CWA concurs wholeheartedly and we are working to ensure this becomes a reality.

Thank you.

Mr. **Bedell**. Thank you very much, Ms. Loble, for you testimony.

Mr. Ray, do you have any questions?

Mr. **Ray**. I would just like to say it was a very excellent presentation and I enjoyed it very much. You pointed out some of the directions in which you recommended that we travel but do we have a specific plan?

Technology is going to advance; we know that. In fact, there is a great cry around the country right now we are losing, or falling behind in technology and that we must catch up particularly in certain areas.

I am on the Armed Services Committee in Defense and we have a problem there with technology to a degree. I am in great sympathy. I have been a small businessman for 22 or 23 years. I built the business. I worked with people. I have a high regard and a strong feeling and a personal concern for folks, but I don't see a clear-cut way for us to deal with this.

Obviously we can't retard technology. We must go ahead in it. I guess we just have to work together with you. The union that you represent of course has been a good one for many years.

I have made a statement and have not asked a question. One question that I do want to ask is: with the break up of the Bell system, as it goes off in a great many different directions, do you see technology moving in and advancing too rapidly with this, or do you see this to the advantage of the worker in any way?

Ms. **Loble**. Well, the whole issue of what is happening in telecommunications is complex to say the least, and in fact it is rather up in the air. First I would like to agree with you that there are many areas in which labor and management can cooperate.

You are correct: we cannot retard the growth of technology. It would not serve any purpose for workers or management or consumers. However, there are serious questions for the implementation of that technology and how that is accomplished.

What are we striving for is to say that the issue of timing and the quality of implementation can be considered and shouldn't just be an arbitrary decision because that is only counterproductive in the long run.

Regarding the break up of Southern Bell, I really don't know. Technology is playing a big part in all aspects of telecommunications. It remains to be seen how it interrelates with deregulation.

I mean the local phone companies will be providing essentially just voice service. The sort of sophisticated data transmission both intra and interstate will be in the AT&T province. Yet the local phone operator is now connected to a very sophisticated piece of machinery and his or her job is being compartmentalized and fractured. I do not know if that answers your question or not, but that gives you some of my perspective.

Mr. **Ray**. I for one share your frustrations and will be working to do what I can on the committee to work with you.

Ms. **Loble**. Thank you.

Mr. **Bedell**. Ms. Loble, first of all I want to commend you and the CWA. I have read your publications and as near as I know you are out in front of everyone pretty much in trying to at least look at the future. That is what this committee is trying to do with these hearings. As we look at the Bell System certainly we are seeing tremendous automation. I use the example of how I now make a long distance credit card call and no operator is involved in the whole process. As you look at that, do you anticipate that there are going to be more jobs for people in the telephone service, for example, or fewer jobs? What is your forecast?

Ms. **Loble**. Well, I could give you both sides of the equation. When we shifted from the cord board operation——

Mr. **Bedell**. Sure.

Ms. **Loble**. To computerized systems, CWA opposed that. This was quite awhile ago, and we opposed it because we felt it would erode the job security of our members.

We now see we were incorrect. What happened was quite the contrary. By adding to the sophistication of the entire industry and vastly expanding its capability, people began to use it much, much more, so overall employment increased.

However, we are also talking about technology that is literally completely replacing jobs and in addition, even if jobs are still there, the question is what kind of jobs are they? For our members, as I tried to point out here, the job is being fractured into simpler components. Thus, one of our proposals for example would be to allow a telephone operator to work for awhile on the TSPS—the traffic service position system—which is the computerized call-transfer system, and allow them maybe in the afternoon to go work in another job.

The idea is that the more boring the job is, the less productive a worker is and it has nothing to do with whether they are unionized or not. It is just a fact of life that the quality of the work life plays an important role in the productivity of that individual worker.

So our proposal would be to allow people to have more variety in their jobs.

Mr. **Bedell**. You see the riddle that I face as an individual and as I try to look at this problem is the one you have brought out, that is, for all of history people have said if we automate and replace people's jobs, it is going to cause us, therefore, not to have work for everyone. In fact, people have been wrong all through history in that regard.

There is an argument to be made, I think with some legitimacy, that that is true. But we have never hit anything quite like this in our history where this was going to happen as fast as it appears that it is going to happen, where we are really going to completely replace people as compared to making their job easier and more productive. I have to tell you, in my opinion we also face the problem which you have quoted. Will there be more janitors and fast food operators and so on? This all comes from the Bureau of Labor Statistics, I assume.

I think this is subject to serious questioning, frankly. We have talked, for example, about typists and secretaries.

It is a great question, and Mr. Etzioni said there are going to be so many more secretaries. I think that is subject to serious question, with automation, whether that is going to be what will really happen.

As long as we say things have always been this way in the past so we better assume they are going to be that way in the future and as long as we depend upon the Bureau of Labor Statistics assumptions for what is going to happen, there is sure some chance we could get ourselves in a terrible, terrible mess by accepting assumptions which we find were true in the past but are not true out in the future.

I do not know what is true in the future but it appears to me that there is at least some reason to question these things, and I think that is what you folks are doing, is it not?

Ms. **Loble**. Yes we are, and we recently spent 1½ years with a rank and file committee calling in every expert that we could think of to try to give us some advice about what the future is, not only for the union but for the industries in which our members are employed.

I do not know how you get around the question. It seems to me there are aspects of the new technology that clearly are going to take away jobs. How do you get around the fact that a robot can do what the individual has done until today?

It may be, and I know that some people put forward this position, that we are going to expand the economic pie to such a degree that everyone will benefit.

The problem with that is that we are again back to what is the quality of participation in this economic pie and what is the distribution. If we are not going to change the distribution, we are just going to merely create a bigger class of people who are excluded from the stimulating high-tech jobs that everybody is saying are going to appear.

Mr. **Bedell**. Most people do not say there are going to be a large number of high-tech jobs.

Ms. **Loble**. No; it is clear that there isn't, in terms of numbers.

Mr. **Bedell**. You hit upon another problem that exists, and you mentioned how the Government tends to have optimistic dreams. That is very normal, Ms. Loble. I don't care if it is a Democratic or Republican administration, historically they have always painted the future, since I have been here, as better than it has turned out to be.

That is natural I think that that would take place. You brought up another thing that I hadn't really thought of before. You mentioned the fact that for many of your workers, they are actually seeing a decline in pay as a result of this automation.

Mr. Etzioni brought up the fact that in order to become competitive in world markets we have seen declines and probably are going to see further declines in workers' pay.

At last, it is my belief that our economy is primarily driven by the purchasing power of the people in our society. When that drops off, you see the whole economy drop off.

If it is indeed true that we can expect to see workers pay decline, and I am even seeing it for example in meatpacking, which does not face foreign competition. I am seeing significant cuts in the pay for my people that work in meatpacking plants.

You could argue they were too high, but whether you argue that one way or another, the fact of the matter is that they are not going to have the same purchasing power that they had in the past.

So, added to the unemployment, it appears to me that you have some argument to be made that people are not going to have the same purchasing power. If that is the case, then is it still realistic to project a growth of GNP of somewhere between 2.5 and 4 percent, which is way higher than we have had in recent years?

Does that make sense?

Ms. **Loble**. I share your consternation exactly.

Mr. **Bedell**. You see in addition to that, more of the tax burden is faced by individuals as compared to corporations so that also diminishes their purchasing power, it seems to me.

Ms. **Loble**. You are exactly right. Economic consequences of this new technology may be seriously creating a whole group of people who are going to be dependent on the Government, beyond those who already are in that unfortunate position, because their jobs are eliminated or are paying so little.

Mr. **Bedell**. Well, I really appreciate your testimony. I am going to have to run because of a vote.

Are you Peggy Canada?

Ms. **Canada**. Yes; I am.

Mr. **Bedell**. I have to apologize to you greatly, but if it is all right with you, I will go run and vote and come right back. I am really most anxious to hear you and I am sorry that I am so interested in this issue that I ask too many questions maybe, but I would appreciate it if you would wait.

Thank you. I will be back just as quickly as I can.

[A brief recess was taken.]

Mr. **Bedell**. I owe you a very deep apology.

TESTIMONY OF PEGGY CANADA, MANAGER OF TRAINING AND DEVELOPMENT, COX CABLE COMMUNICATIONS

Ms. **Canada**. Thank vou.

I really feel somewhat out of place because I represent a person who happens to be coping with technology, as a professional who earns her money that way. Our company is in a position of having to respond to the influences of high technology because of the cable industry, so my perspective is somewhat different than some of the other witnesses who have come from an analytical perspective. However, I am very pleased to have this opportunity to speak on the impact of technology, on education, and training.

While I realize that this session is geared more toward the small business owner, the technology impact is generic to all companies. Regardless of size, high technology is changing the way companies do business.

To begin, I would like to give you my definition of high technology. To me, high technology is a knowledge-based industry as opposed to a natural resource-based industry.

Its products are based on special knowledge transferred to services or goods. Like molecular action, high technology is in a constant state of flux. Its perpetual evolution and revolution has sparked new industries, mainly companies which repair, service, and supply the high technology area.

This is a gold mine for mass employment opportunities. Today, my home city of Atlanta is actively engaged in a campaign to become the South's Silicon Valley.

The base for this effort is software, telecommunications, defense electronics, biology, and genetic science, energy and computer-supported design and manufacturing companies.

Multimillions of dollars are being spent to build and house these firms. The biggest hurdle to this industry growth is a lack of trained workers. As an aside, I believe there was an article in the Post this morning that we lost a bid for a consortium that went to Austin, Tex., as opposed to Atlanta because, as we understood it, of the schooling available Austin had a curriculum that was more relevant to the job opportunities that they would have.

In Atlanta alone, there are approximately 158 new technological companies that have sprouted up that employ anywhere from 4 to perhaps 135 employees. But in total, they have opened up approximately 33,000 jobs in the last year and a half. The cadre of trained workers begin with their education at the secondary level. In reviewing the secondary school curriculum, I do not see courses reflecting today's business trend which is high technology and the support services trades.

Today's environment is a high tech, proficient skills, information processing world. The skills needed to support this world are mechanical, electrical, and data processing. However, the secondary schools are not providing the basic math and science skills to support this environment. Our high school dropout rate of 23 to 25 percent is matched by an 8 percent dropout rate in Japan and a 2 percent rate in Russia.

Even those students finishing school these days aren't such great shakes. Only one-third of the Nation's 17,000 school districts require more than 1 year of math and science. And on top of that, up to 20 percent of our high school students are functional illiterates. The upshot of that is that business has to deliver not only technical training but some pretty basic "little red schoolhouse" stuff as well. Interestingly enough, all of the industrial trade publications tell us that robotics and smart machines are going to require chief maintenance technicians who will replace wrenches with computer terminals and troubleshooting programs. Machine repair people are going to have to develop operation monitoring and preventive maintenance skills of an extremely high caliber. New equipment will be designed to work well and long, so down equipment will really be down and will require heavy-duty problem solving to get it up again. Products of new technologies and new factories will require new and different maintenance and technical training. Where are the high school courses to begin this educational need? In industries' opinion, high schools should still offer and require the traditional skill course, and certainly require more than 1 year of math and science. Since high schools are not producing this second and third level of skill support, it is industries who are providing this training. By determining this, public schools can establish priorities for their programs. However, the name of the game is change, and the schools must react quickly to the ever-occurring changes technology imposes on business. Once the occupations have been selected for training, the next step is to determine the content of the instructional program. A critical component is the occupational skills needed for successful performance on the job. However, occupational skills must be combined with basic skills. These basic skills include reading, writing, mathematics, and verbal communications. As the occupational skills are developed, students also need to be aware that employees want workers who have good work habits, dress appropriately, avoid waste, arrive at work on time, perform their duties conscientiously, and follow instructions.

A valuable method for training people is apprenticeship. Apprenticeship may be inaccurately perceived by some to mean a training model for teaching low-level skills and, therefore inappropriate as an educational program model.

These people are bypassing a model by which they could legitimately prepare students for a variety of occupations requiring sophisticated integration of industry and education.

Apprenticeship is an educational model which involves on-the-job training and related instructions. Many professions require the integration of education and job training. In each profession, the proportions of theory and practice in training are determined by the complexity of the theoretical foundation and the specific skills development needed.

Technology can constantly change these requirements which must be evidenced in the training. Most vocational and technical educators agree that their goal is the integration of education with job performance.

Man believe that adequate job training can occur within school workshops and labs. Just as their curriculum is behind the times, this attitude is unrealistic.

Analysis of most inschool programs uncovered three major shortcomings: Both students and employers suffered from unrealistic expectations; students often lacked essential knowledge; students invariably lacked workplace sophistication.

Graduates of inschool programs went to their employers assured that, if they did not know it all, they knew most of it. Employers, on the other hand, expected the graduates to be knowledgeable and skillful and to be immediately productive.

Gaps in student knowledge and the lack of workplace sophistication dismayed their new employers. Too often, graduates lacked specific knowledge which the employer believed essential to competent performance. In addition, the new employees appeared uncomfortable in the work environment and lacked effective coping and problem-solving skills for the first few months of employment.

Graduates of apprenticeship programs experienced few of these problems and, according to their employers, were usually immediately productive employees. A good example of a viable apprenticeship program is the one at the Community College of Allegheny County, in Pittsburgh, Pa. At CCAC, students are not admitted into a formal apprenticeship program until they have completed 10 credits of introductory inschool studies in the preapprenticeship phase.

Also, students are not admitted until they have secured full-time jobs in their chosen profession. They are assisted in this by program coordinators who work with them and employers for placement. In this apprenticeship model, problems of unrealistic expectations were eliminated. Employers were informed that they were part of the education process and were responsible for helping the student become a competent employee.

The student approached the apprenticeship experience with the understanding that 3 years of training remained. Apprentices were placed on escalating wage scales with full benefits and substantial financial incentives.

Employers, knowing that apprentices were being trained to assume full productivity within 3 years, bided their student/employees' progress carefully. In this setting, apprentices worked hard, aware that dismissal from their jobs would mean dismissal from their apprenticeship programs.

Apprentices graduated from the CCAC program after part-time studies of 4 years and full-time employment of 3 years with: an associate degree, journeyman papers, 3 years of seniority, and placement high on the wage scale. In contrast, nonapprenticed students complete the inschool program with: an associate degree, no journeyman papers, no job experience, placement at an entry level salary substantially below that of a journeyman, and unrealistic job expectations.

Rather than build and equip high technology labs, the school works closely with industry to design programs that incorporate the apprenticeship concept. Inhouse training conducted by companies must also reflect the impact of technology on the way they do business.

There is a multiplicity of training requirements that must be accomplished: Preemployment programs, programs to upgrade current employees, inservice programs to update employees with the latest technology, remedial programs to address performance weaknesses. Whatever the training program level is, the purpose of the program is to prepare employees to perform a single operation, to prepare them to grow in their jobs and to adapt to changes in their job.

After all, the basic operations remain the same; it is the machines, tools, and materials that will change. Whether the training or education activity is conducted inhouse by industry or by an outside educational institution, an analysis of the occupation for which the activity is being planned is essential. A partnership between industry and education is not only desirable but essential. If one person's reality is not to be another person's fantasy, this partnership will insure the validity of occupational analysis and resultant education programming.

In conclusion, high technology demands rapid change. Education as well as business must be able to react in a timely manner. The era of the 5-year strategic plan is gone.

Companies can strive for long-term direction but the day-to-day operating reality is that of 1 year. In this highly volatile environment, change is constant.

Our schools must also adopt this attitude. They cannot take 1 to 3 years to produce a change in their curriculum. They must implement a structure that is responsive and flexible to today's training needs of business and industry.

Just as technology demands companies change the way they do business, technology also demands that schools change the way they structure their curriculum. In listening to the testimony this morning, I have to indicate that at Cox Cable, we are in a mode of training approximately 3,000 to 4,000 employees in a change in the way they do business in all of our cable offices.

We are taking them from a manual system to a computer system that is termed on-line, that inputs all information to Atlanta, which is our corporate headquarters. We process that information and give them immediate response. This has helped in capturing a lot of our receivables in billing. In going about and developing that training program and then actually implementing it, we are not losing any employees.

In fact, we are adding onto the payroll of each cable office by a minimum of 3 to 5 and sometimes up to 10 employees because of the computerization and the fact that we can get more productivity with more people that way.

We have not found that management is taking on more of the employees' responsibilities. If anything, management is decreasing because they now have reports as tools rather than having to be hands-on, eyeball-to-eyeball type of supervision.

We have found certainly that payroll has not decreased. If anything, based upon the skills that we have trained our employees in, the demand for a higher hourly wage has increased.

I have to say that I am at odds with some of the testimony that has been presented this morning from our own experience from one company.

Mr. **Bedell**. We certainly appreciate that. I think that is one of the problems this committee faces, the differences of opinions. If the hearing in the past few days impressed me with one thing, it is that so much of what we are going on is opinions rather than facts, like the Bureau of Labor Statistics, for example.

Whether or not there are going to be more or less secretaries really mostly depend on their opinions when you get right down to the reality. Unless I misunderstand what is happening, most all consultants and futurists accept those as facts, which could cause serious troubles if they are wrong.

Ms. **Canada**. In my opinion, they are wrong. I owned a small company that employed 7 people as a management consultant. I had two word-processing employees.

In my company alone, you can't find a typewriter. It is all word processing.

Mr. **Bedell**. So you believe the proposal that typists are going to be one of the 18 most rapidly growing professions in terms of needs of people is pretty questionable, I take it?

Ms. **Canada**. Yes.

Mr. **Bedell**. We also had some testimony to indicate that because of the fact that there are so many people looking for the few jobs that are available that we are not going to solve our unemployment problem by simply retraining people.

I think as you look at that testimony, however, it does not particularly conflict with what you are saying. I do not think that witness meant to imply that there was not a need to train people for the new jobs that are going to be demanded. Indeed, we should give them some practical training as well, would be my impression.

I take it that you feel very strongly that the type of practical training that you are giving is imperative in the new times that we have. Is that correct?

Ms. CANADA. Yes. I think my reality is working with employees, not only from my own staff of trainers who also have to adapt to change as I do, but also what one would term hourly employees. You can go in with all of the nice whipped cream and cherries and talk to these people and say you are going to change from writing out work orders to inputting them on a CRT, and we are here to train you.

We try to do that with the best behaviorial psychology that we can employ in the training program, but bottom line is, you are going to have to change the way you do your job or you are not going to have the job.

In fact, all of the employees that I have worked with in the cable offices that we have dealt with have been for the most part very receptive to the change and even though a little bit frightened at first, have come to enjoy the new way of going about their day-to-day activity.

I have found that we have not lost employees at all because of this concern that our company has for not displacing employees just because automation and technology has created a different approach to the way they do their day-to-day activities, but it does require that they be humanly flexible.

Also, on the other hand, you have new businesses starting up that are creating a whole wealth of new jobs out there. They require different skills, but they still require a person with two arms and a mouth to perform those skills.

So you have to come at it from two different avenues, but I don't really see where it is displacing people other than changing the way they do business.

Mr. BEDELL. In your work where you have been training people, have you had any experience in training people such as steelworkers or automobile factory workers? The argument that comes forth is it is going to be very difficult for those types of individuals to adjust into the new types of jobs that might be available for them which you would assume would be much lower pay jobs and quite different types of skill requirements.

Ms. CANADA. I haven't had any personal experience in training steel or automobile people. I have worked with trainers, General Motors and Ford and Chrysler, who are in that position.

Mr. BEDELL. I'm sorry, Mr. Ray. You do apparently need to get to another appointment. I would go ahead and yield to you.

Mr. RAY. Mr. Chairman, I apologize. Ms. Canada is from my own State of Georgia. I was going to introduce her and I got caught on the floor over there as we do many times and it seems like this morning has been a very difficult one for me. I thank you for coming. In reading your testimony and hearing you, you are enthusiastic and receptive to technology in the future and it sounds encouraging to me that you seem to be reaching out and feel that this is indeed an exciting time that we are in. Am I reading that right?

Ms. CANADA. That's absolutely right.

Mr. RAY. I am from the central area of Georgia where we have had a great amount of minority labor through the years in various types of menial-type jobs, farms and so forth, and this technology has come along, the new farm equipment and the new mechanized equipment at some of the plants.

In textiles, for instance, it has thrust a great number of people onto the markets with really nowhere to go. So I think we do have a tremendous challenge here with us, Mr. Chairman, as we cope with a whole segment of society.

I don't want progress to slow down one bit. I think we've got to have this. I think we are going to be moving forward in that area. But I do believe that we are going to have to gear up our vocational/technical schools in certain areas to start really concentrating and coping more so than we are doing right now in some of these particular areas.

During the last year, 1982, during my campaign, I talked to many educators who were greatly concerned that high school graduates now reaching college age have no knowledge of the sciences of math and physics, and that they are going through these schools getting degrees that are just not marketable on the open market.

There again I guess I am testifying before the committee here, but I believe that educators themselves are going to have to come to the rescue of some of these younger people who are now coming into the labor markets with no skills.

One thing that disturbed me last year was that five Ph.D's were going through the retraining process in the vocational/technical schools because they had been on the market for 15 months and they were not able to market their degrees.

At Robbins Air Force Base in our district, there were hundreds of avionics and electronics-type jobs and they were searching all over the United States hunting these people.

So I, too, look forward with excitement to the future but am greatly concerned right now with our work here on this committee on how we are going to approach and look at these people who are going to be caught in the short run.

Thank you, Mr. Chairman.

Mr. BEDELL. Thank you very much, Mr. Ray.

One other thing you mentioned that I wanted to question you a little about. You indicated in your opinion that we are actually seeing a decrease in, I guess you would call it, white collar jobs or management jobs. This was also pointed out by one of our witnesses yesterday in terms of fewer layers of management because automation had made this information more readily available to higher management people without the necessity of having people to transmit such information. Apparently you concur in that. Is that right?

Ms. CANADA. Yes. I think that again the job description is changing and you are branching off with a lot of what was termed first level supervisory even to some of the lower level middle management.

Their job function has changed to a certain extent where you used to have say five employees and a supervisor and then a manager over the supervisor, et cetera.

We do not have that anymore because the reporting capability of the automation, whether it is via computers or word processing, has taken the place of having a person report back to you on a daily basis on the productivity of the employees because it is right there in figures.

However, that has created another problem or challenge for training in that we have got to educate our management on how to use all of these reports coming in and to best utilize the workers that we have for the productivity that we are looking for.

Mr. BEDELL. Do you have a question, Mr. Fithian?

Mr. FITHIAN. I have just two to round out the record, Ms. Canada. One, some of the literature would indicate that the march of high tech into the work place tends to polarize the kinds of skills that are required in a given industry, that is 30 or 40 percent of the jobs in the process will be very exciting—engineers, computers, management, people like yourself and so on. At the same time it substantially reduces the skills required for the rest of the workers in that high tech industry. Those workers end up doing entry level, assembly type functions and so on. Is that perspective, that I am beginning to pick up from some, correct in your view?

Ms. CANADA. I don't know if it is correct or not, but from my experience it is not correct.

Mr. FITHIAN. It is not. The second question is: One of the policy issues being talked about around here now is that in order to cope with this rampant training and retraining which high tech and the rapid change in the work place require, a system ought to be initiated whereby workers would have at their disposal a training voucher plan. They and management would pay into this over the years until a certain amount had been built up. If they are structurally displaced, they would draw on that in the way that you would draw on an IRA. Some are calling them the IRA work accounts, for training and retraining or acquisition of new skills. What would you think of that particular proposal?

Ms. CANADA. Well, from a company point of view, the company is very concerned about the displacement of workers. I find that an hourly worker more often than not does not think about the future. So it would be very hard to convince that person to take a certain percentage of his paycheck and put it into this pool for future education that may or may not materialize based upon what may or may not be doing, because there is a basic feeling of security that the employer will take care of me and give me the training necessary to do the job.

I think it would certainly warrant more investigation but I would hold my judgment on that until I saw some more data to prove out that this would be really workable or not, just another idea that was come up with, because training is going to be ongoing.

Even when you take a construction industry, the knowledge that the workers have to have in being able to work either in remodeling our new building because new equipment is coming out.

Even if you take a look at the heavy duty equipment, just in running that heavy duty equipment, is changing because it is becoming more computerized and you can't really wait until you build up a pot or until you determine that now is the time to go and send this person to school after they have been building up into this pool for 2 or 3 years, because by then it has all changed.

If there is one point that I want to leave in the testimony is that it was wonderful to be able to deliberate and gather all the facts and go through the basic decision making steps that we used to do traditionally in business, but you cannot do that today.

You don't want to be impulsive, but you cannot allow yourself to lag behind making the decisions necessary to make sure that you are viable and that you are current and that you are competitive, even in a small company.

My husband is a general contractor and I talked him into getting a word processor and personal computer because it saves so much time and he was very reluctant to do that.

He is just a one-person owner that subcontracts everything out, but he needed to do it to make more money and that is what the name of the game is for us anyway, is to make more money.

Mr. BEDELL. I think that last comment is one of the main puzzles that we face and that question is: How fast is change going to take place during the next 10 years?

Mr. Etzioni said, for example, that there would be less than 1 percent change in the makeup of our work force per year. I am not here to argue that, but I think there is some evidence to indicate that we are going to see change in the next 10 years much more rapidly than we have seen in the past. I take it that is your opinion?

Ms. CANADA. It is my opinion. It is also my experience, just relating to you our yearly budgetary traditional practices that we go through.

We are on a fiscal year and we will be going into our budgeting process to be consummated by August to go into 1984, so naturally we have to make some assumptions.

But we have learned in our company that usually from experience we will project our figures and then based upon what happens to be happening to us at that particular time, any relationship between the figures that we budgeted and the actual expenditures that we are going through for the year that we budgeted are totally apart.

Mr. BEDELL. That would be more so today than you think it would have been 5 years ago?

Ms. CANADA. Absolutely. Five years ago you really could do a 3- to a 5-year plan and you could really be methodical in plotting out your direction. That does not mean that we are still not accountable for coming in within the dollar figures, but it means that I have got to make decisions in manipulating those figures, where before I would not have had the leeway in another industry to do that.

I am actually robbing from Peter to pay Paul so that I come down bottom line with my budget. But it has no relationship to what I thought my direction for my center was going to be. We coined a phrase and that is a fact that my department turns on a dime.

[Ms. Canada's prepared statement follows:]

PREPARED STATEMENT OF PEGGY CANADA, MANAGER OF TRAINING AND DEVELOPMENT, COX CABLE COMMUNICATIONS

I am very pleased to have this opportunity to speak on the impact of technology on education and training. While I realize that this session is geared toward the small business owner, the technology impact is generic to all companies. Regardless of size, high technology is changing the way companies do business.

To begin, I would like to give you my definition of high technology. High technology is a knowledge-based industry, as opposed to a natural resource-based industry. Its products are based on special knowledge transferred to services or goods. Like molecular action, high technology is in a constant state of flux. Its perpetual evolution and revolution has sparked new industries—mainly, companies which repair, service and supply the high technology areas. This is a goldmine for mass employment opportunities. Today, my home city of Atlanta is actively engaged in a campaign to become the South's "Silicon Valley." The base for this effort is software, telecommunications, defense electronics, biology and genetic science, energy and computer supported design, and manufacturing companies. Multi millions of dollars are being spent to build and house these firms. The biggest hurdle to this industry growth is a lack of trained workers.

The cadre of trained workers begin with their education at the secondary level. In reviewing the secondary school curriculum, I do not see courses reflecting today's business trend which is high technology and the support services trades. Today's environment is a high tech proficient skills, information processing world. The skills needed to support this world are mechanical, electrical, and data processing. However, the secondary schools are not providing the basic math and science skills to support this environment.

Our high school dropout rate of 23 to 25 percent is matched by an 8 percent dropout rate in Japan and a 2 percent rate in Russia. Even those students finishing school these days aren't such great shakes. Only one-third of the Nation's 17,000 school districts require more than 1 year of math and science. And on top of that, up to 20 percent of our high school students are functional illiterates. The upshot is that business has to deliver not only technical training but some pretty basic "little red schoolhouse stuff" as well.

Interestingly enough, all of the industrial trade publications tell us that robotics and smart machines are going to require chief maintenance technicians who will replace wrenches with computer terminals and trouble-shooting programs. Machine repair people are going to have to develop operation monitoring and preventive maintenance skills of an extremely high caliber. New equipment will be designed to work well and long, so "down" equipment will really be down and will require heavy-duty problem solving to get it "up" again. Products of new technologies and new factories will require new and different maintenance and technical training: where are the high school courses to begin this educational need? In industries opinion, high schools should still offer *and require* the traditional skill courses—and require more than one year of math and science.

Since high schools are not producing this second and third level of skill support—it's industries who are providing this training; if industry has the time and resources to do so.

Vocational schools are not exempt from this responsibility either. One would tend to think that vocational schools would be an ideal avenue for small business to recruit skilled personnel. Since financial resources are limited for training employees, what better employment agency is there than vocational schools. But the schools have not changed their curriculum to reflect today's employment needs.

The trend toward growth in business and industry training has been noted by public educators and attempts have been made to speculate on the implications of the trend for the future of public education. Numerous efforts are underway to improve the connection between school and work.

Existing job opportunities and future employee needs provide the basis for selecting occupations for which public vocational programs need to be offered. Sources of local employment data are: business and industries, State employment commission, State occupational information coordinating committees, chambers of commerce, etc. after identifying the occupations in which employment opportunities exist, the next consideration is whether the occupations require pre-employment training. By determining this, public school can establish priorities for their programs. However, the name of the game is change, and schools must react quickly to the ever occurring changes technology imposes on business.

Once the occupations have been selected for training, the next step is to determine the content of the instructional program. A critical component is the occupational skills needed for successful performance on the job. However, occupational skills must be combined with basic skills. These basic skills include reading, writing, mathematics, and verbal communications.

As the occupational skills are developed, students also need to be aware that employees want workers who have good work habits, dress appropriately, avoid waste, arrive at work on time, perform their duties conscientiously and follow instructions.

A valuable method for training people is apprenticeship. Apprenticeship may be inaccurately perceived by some to mean a training model for teaching low-level skills and, therefore, inappropriate as an educational program model. These people are bypassing a model by which they could legitimately prepare students for a variety of occupations requiring sophisticated integration of industry and education. Apprenticeship is an educational model which involves on-the-job training and related instructions. Many professions require the integration of education and job training. In each profession, the proportions of theory and practice in training are determined by the complexity of the theoretical foundation and the specific skills development needed. Technology can constantly change these requirements which must be evidenced in the training. Most vocational and technical educators agree that their goal is the integration of education with job performance.

Many believe that adequate job training can occur within school workshops and labs. Just as their curriculum is behind the times, this attitude is unrealistic. Analysis of most in-school programs uncovered 3 major shortcomings:

Both students and employers suffered from unrealistic expectations

Students often lacked essential knowledge.

Students invariably lacked workplace sophistication.

Graduates of in-school programs went to their employers assured that, if they did not 'know it all' they 'knew most of it'. Employers, on the other hand, expected the graduates to be knowledgeable and skillful and to be immediately productive. Gaps in student knowledge and the lack of workplace sophistication dismayed their new employers. Too often, graduates lacked specific knowledge which the employer believed essential to competent performance. In addition, the new employees appeared uncomfortable in the work environment and lacked effective coping and problem-solving skills for the first few months of employment.

Graduates of apprenticeship programs experienced few of these problems and, according to their employers, were usually immediately productive employees.

A good example of a viable apprenticeship program is the one at the Community College of Allegheny County, in Pittsburgh, Pa. At CCAC, students are not admitted into a formal apprenticeship program until they have completed 10 credits of introductory in-school studies in the preapprenticeship phase. Also, students are not admitted until they have secured full-time jobs in their chosen profession. They are assisted in this by program coordinators who work with them and employers for placement.

In this apprenticeship model, problems of unrealistic expectations were eliminated. Employers were informed that they were part of the educational process and were responsible for helping the student become a competent employee. The student approached the apprenticeship experience with the understanding that three years of training remained. Apprentices were placed on escalating wage scales with full benefits and substantial financial incentives. Employers, knowing that apprentices were being trained to assume full productivity within three years, guided their student/employees' progress carefully. In this setting, apprentices worked hard, aware that dismissal from their jobs would mean dismissal from their apprenticeship programs.

Apprentices graduate from the CCAC program after part-time studies of 4 years and full-time employment of 3 years with: (1) an associate degree, (2) journeyman papers, (3) 3 years of seniority, and (4) placement high on the wage scale.

In contrast, nonapprenticed students complete the in-school program with: (1) an associate degree, (2) no journeyman papers, (3) no job experience, (4) placement at an entry level salary substantially below that of a journeymen, and (5) unrealistic job expections.

Rather than build and equip high technology labs, the school works closely with industry to design programs that incorporate the apprenticeship concept.

In-house training conducted by companies must also reflect the impact of technology on the way they do business. There is a multiplicity of training requirements that must be accomplished. Pre-employment programs, programs to upgrade current employees, in-service programs to update employees with the latest technology, remedial programs to address performance weaknesses.

Whatever the training program level is, the purpose of the program is to prepare employees to perform a single operation; to prepare them to grow in their jobs and to adapt to changes in their job. After all, the basic operations remain the same; it's the machines, tools and materials that change. Whether the training or education activity is conducted in-house by industry or by an outside educational institution, an analysis of the occupation for which the activity is being planned is essential. A partnership between industry and education is not only desirable but essential. If one person's reality is not to be another person's fantasy, this partnership will insure the validity of occupational analysis and resultant educational programing.

In conclusion, high technology demands rapid change. Education as well as business must be able to react in a timely manner. The era of the 5 year strategic plan is gone. Companies can strive for long term direction but the day-to-day operating reality is that of one year. In this highly volatile environment change is constant. Our schools must also adopt this attitude. They cannot take 1 to 3 years to produce a change in their curriculum. They must implement a structure that is responsive and flexible to today's training needs of business and industry. Just as technology demands companies change the way they do business, technology also demands that schools change the way they structure their curriculum.

Mr. BEDELL. Thank you very much for you testimony. We appreciate it very much.

Ms. CANADA. Thank you.

Mr. BEDELL. We appreciate the fact that it has been so late and I apologize to you for the lateness of the hour.

Ms. CANADA. Thank you.

Mr. BEDELL. Thank you.

The hearing will be adjourned.

[Whereupon, at 12:46 p.m., the subcommittee adjourned, to reconvene subject to call of the Chair.]

APPENDIXES

APPENDIX A.—QUESTIONS TO AND RESPONSES FROM WESTINGHOUSE ELECTRIC CORP.

Question. How rapidly do you see the market for numerically controlled machines expanding? Project for us the 1980's. Estimate the 1990's.

Answer. The U.S. market for numerically controlled machines, measured in constant dollars, has been flat for the past 6 or 7 years. However, the cost of each numerical control has been declining while the percentage of machine tools shipped with numerical controls has been increasing. Presently, only 15 percent of the machine tools manufactured in the U.S. have numerical controls associated with them. This percentage will continue to increase.

Westinghouse specializes in numerically controlled machines for the aerospace industry. In this industry, the percentage of machines requiring numerical control is much higher.

Question. What industries are the most likely users of robots, numerically controlled machines, etc.?

Answer. Currently, the heaviest usage of robots occur in the metalworking industry, particularly in the automotive segment. While we will continue to see widespread use in a variety of metalworking applications, in the 1980's we will see robots used in all manufacturing, from light electronic to heavy industrial, working in assembly and material handling processes, etc. Labor costs in all major industries will allow economic benefits when more than one worker can be replaced by a robot.

In the first half of the 1980's, the aerospace and defense industries will be the most significant new users of robotics and factory automation.

Question. What are the functional limitations of robots? Of other automation with which you are familiar? Please address the physical limitations.

Answer. Functional limitations can be categorized in three interrelated ways: physical, economical and technological.

Actual physical limitations for robots come into play when the object to be manipulated weighs more than 1,000 pounds or is longer than 10 feet. These limitations are set by economics, not by technological deficiencies. There are too few applications with these requirements to warrant development expenses.

Similarly, precision manipulators—robots which can position accurately and repeatably to plus or minus .001 of an inch—are becoming more common but are limiting economically unless their production volume merits the development costs. Most robots still are not very accurate. (The significance of accuracy in robots is that an accurate robot can be programmed off-line at a CAD system while an inaccurate robot must be programmed on the factory floor, using the robot arm to create the program.)

The true technological limitations are intelligence/sensor-related. Many manufacturing tasks call for judgment on the part of the worker. Currently, robots are not capable of analyzing complex situations and making decisions. That is the main barrier to implementing robotic systems to replace workers.

The degrees of economic or technical risk also are limiting factors. An economic risk, or detriment, to investment in robots is the dollar magnitude of an 'automating' project. Current costs discourage all but multiple shift, capital intensive industries (15 percent to 17 percent of the potential market) from investing readily in robotics.

The technical risks involved in automating will diminish as robot functions and applications become more sophisticated. Factory automation involves a trade-off between application engineering, tooling, fixturing and general purpose devices. Presently, most robot installations function with the assistance of large amounts of application engineering, tooling and fixturing. In the future, as sensors become more commonplace with robots, internal vision and tactile sensing will enable robots to operate with reduced needs for initial investment in application engineering and expensive tooling and fixturing.

Question. Describe the next generation of robotics for us. What is not in the lab but definitely on the way? The "smart" robots question.

Robot development will continue to be evolutionary, not revolutionary. Today's robot mechanisms will be considered crude and rudimentary as developments in the areas of sensors (2-3 years) and mobility (4-5 years) evolve. Each of these technological advances will open new opportunities to replace workers who are doing routine jobs.

Examples: The robot control will be able to handle multiple arms simultaneously. Enough computer power will be available to allow rudimentary forms of artifical intelligence to operate as part of the robot, and the robot will have communication links to other parts of the factory. The military will lead in the development of mobile robots, with vision systems that can detect obstacles.

In the future, we must also concentrate on driving the cost of robots down by increased volume, through new or expanded markets and through increased technological sophistication and innovative design that will decrease the risk of investment.

APPENDIX B

DRAFT

THE IMPACTS OF AUTOMATION ON EMPLOYMENT, 1963-2000

Abstract and Executive Summary of Final Report

by

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with Daniel Szyld, Jesus Alvarez, David Howell, Michel Juillard, Catherine McDonough, Glenn-Marie Lange, and Dimitri Turchin

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March 1984

This report is based upon work supported by the National Science Foundation under contract #PRA-8012844. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation.

The Impacts of Automation on Employment, 1963-2000

by
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Abstract

Issues. There is no doubt that computers and computer-based automation will have far-reaching effects on the U.S. economy and society. There is a broad range of views in the scholarly literature and popular press about the nature and extent of these effects. Government policies, however, should and can be based not on opinion, but, so far as possible, on concrete, detailed analysis of the probable impacts of the impending technical changes. Only action based on such anticipation will be able to reduce the individual and social costs that belated adjustments to unanticipated structural shifts will entail.

Methodology. This study incorporates a large body of quantitative information from diverse, especially technical, sources into an input-output model of the U.S. economy to draw a comprehensive and internally consistent picture of the progressive introduction of computers and of various forms of computer-based automation into 89 individual industries comprising the entire economy. It spells out in great detail the probable effects of these technological changes on outputs and inputs of all goods and services and in particular on the demand for labor services described in terms of 53 different occupations. These projections are based on four alternative scenarios about future technological change.

A fully integrated, dynamic input-output model, developed for this study, provides the analytical framework for capturing not only the direct but also the indirect effects of all these changes. In particular it takes into account the effects of technological change on the investment requirements of all the different sectors and the corresponding changes in the outputs of capital goods producing industries.

Findings. The intensive use of automation over the next twenty years will make it possible to conserve about 10% of the labor that would have been required to produce the same bills of goods in the absence of increased automation. The impacts are specific to different types of work and will

involve a significant increase in professionals as a proportion of the labor force and a steep decline in the relative number of clerical workers. Production workers can be expected to maintain their share of the labor force; direct displacement by specific items of automated equipment (like robots and numerically controlled machine tools) will be offset during this period by the increased investment demand for all sorts of capital goods, especially computers.

Computations that assume the full utilization of the projected future labor force suggest that per capita personal and government consumption will be able to grow at about 2% a year in real terms through the 1980's and about 1.0 - 0.5% (under alternative population projections) through the 1990's due to the adoption of computer-based automation in the absence of other structural changes. Whether or not the smooth transition from the old to the new technology can actually be realized will depend to a large extent on whether the necessary changes in the skill structure of the labor force and its distribution between different sectors of the economy (and geographic locations) can be effectively carried out. The study projects the direction and magnitude of these changes in the structure of the labor force and of the educational and training efforts needed to carry them out.

1. Introduction

The opinions expressed in the scholarly literature as well as the popular press about the impacts of automation on employment cover a wide range, from assurance that declining rates of growth of the labor force in the 1980's and 1990's will more than compensate for any loss of jobs to predictions that the manufacturing labor force will fall from over 25 million now to less than 3 million by 2010. We are told that some jobs will become more technical and complex than ever but also about the prospects for a "deskilled" workforce of sweepers and button-pushers. Most observers agree about painful "adjustment" and the needs of retraining, often in the context of measures to ease the "transition" to some automated future which remains entirely unspecified.

Barely beneath the surface of these debates there are clearly passionate social, political, and philosophical differences. In this report, we develop and illustrate a fact-finding and modeling approach that promises to be fruitful in the dispassionate analysis of these issues. After ascertaining the operating characteristics of the already existing, newly developed types of computer and computer-based equipment, we proceed to derive the consequences of alternative assumptions concerning future rates of introduction into the different industries. Taking into account the corresponding changes in the combination of other inputs, particularly labor inputs, we insert the appropriate figures (combinations of so-called technical input coefficients) into a dynamic input-output model and use it to trace the direct and indirect effects of these technical changes on the future levels of output and input--particularly labor inputs--throughout all sectors of the economy.

While there is no shortage of "expert" estimates of isolated numbers (like the sales of computers in 1990), the specialized literature in this area is still very limited, and robotics seems to be the only aspect of automation that has been studied at all systematically to date.

While technical studies like those that have so far been carried out only for robotics must be welcomed and encouraged, their detailed findings need to be incorporated with the results of other similar studies into a comprehensive analytical framework before valid general conclusions can be drawn. It is precisely such an effort, based on a newly formulated and implemented dynamic input-output model of the U.S. economy, that is described in this report. This research goes far beyond what has been attempted in any existing studies in providing a firm and credible basis for the detailed assessment of the economywide impacts of automation on future employment prospects.

2. Methodology

The state of the national economy in each year over the time interval 1963-2000 is described in terms of commodity flows among 89 producing sectors comprising the entire U.S. economy and labor inputs absorbed by each of them specified in terms of 53 occupations. Numerical data are organized for each year into four matrices of technical parameters describing the input structures of all sectors of the economy during that year. These matrices specify the input requirements on current account, capital expansion and replacement requirements, and labor inputs per unit of its respective total output for each sector. Vectors of non-investment final deliveries, including household consumption, government purchases, and net exports are also required. For past years, government agencies produce official series containing most of this information.

Figures describing future technological options have been assembled as part of separate sector studies which ultimately yielded descriptions of alternative input structures, that is, columns and rows of technical coefficients that are inserted into the technical matrices, and a projected vector of non-investment final deliveries for future years. For this report the fact-finding efforts were concentrated on the systematic study of the use of computers used to automate production and office operations, as well as the potential for automation in providing education and health care.

A dynamic input-output model was developed for this study and is used to project year by year from 1963 to 2000, the sectoral outputs and investment and labor requirements of the U.S. economy under alternative assumptions about its changing technological structure. Each set of such assumptions is a scenario. (By "scenario" we mean a set of assumptions about certain aspects of the economy. When the implications of the scenario are computed, projections of other aspects of the economy are obtained. The word is also used to mean both the assumptions and the projections implied by them.)

Four different scenarios, S1, S2, S3 and S4, tracing four alternative paths that the U.S. economy might follow between 1980 and 2000, were formulated and computed for this study. These scenarios were selected with the view of bracketing among them the upper and the lower limits of the rates at which different sectors of the U.S. economy might be expected to adopt the new technology. The reference scenario, S1, represents the changing input-output structure of the economy, year by year, between 1963 and 1980, but assumes no further automation or any other technological change after 1980: in other words, from 1980 on, robots, numerically controlled machine tools, and automated office equipment, to name a few examples, are used only to the extent that they figured in the average technologies that prevailed in 1980. Final deliveries, however, are assumed to continue to grow over a projected path through 2000. The computation of this scenario is thus an experiment that allows us to assess future employment and other requirements to satisfy plausible final deliveries in the absence of technological improvements from 1980 on.

Scenarios S2 and S3 are identical with S1 through 1980 but differ in their technological assumptions for the later years. Both scenarios project an increasing use of computers in all sectors for specific information processing and machine control tasks and their integration. Computerizing each task also involves changes in other inputs, notably labor inputs. While the details are different in each case, Scenario S3 assumes faster technological progress and the more rapid adoption of available technologies than does S2: for example, fewer programmers for the effective use of a computer and more rapid elimination of human drafters. Under both scenarios, the demand for computers (measured in constant prices per unit of output) is naturally higher in 2000 than in 1990.

These scenarios also represent the greater use of two other microprocessor-based devices, robots and computer numerically controlled (CNC) machine tools, for specific manufacturing operations. Scenario S3 assumes a faster replacement by robots of six categories of production workers in many manufacturing sectors (and associated savings in paint where applicable). It also implies faster substitution than S2 of CNC for conventional machine tools and greater savings per tool in steel scrap leading to corresponding reductions in direct requirements for the metalworking occupations.

Both scenarios assume that computer-based workstations will replace conventional office equipment, and that most deliveries after 1985 will be for integrated electronic systems rather than stand-alone devices. The process is accelerated under Scenario S3 where, for example, conventional typewriters are no longer produced after 1985. Corresponding direct impacts on the demand for managerial, sales, and six categories of clerical workers in different sectors of the economy are represented in detail.

Scenarios S2 and S3 assume the continuation of recent trends in the input structures of the health care sectors: notably increased use per case of various types of capital equipment for diagnosis and treatment, of drugs and other chemicals, and of plastic disposable items, as well as an expansion of nonphysician medical personnel. These changes proceed more rapidly under Scenario S3 than S2. The health care sectors also continue the automation of office-type operations, with the direct consequences described above. Under Scenario S1, there are no structural changes, in these or in other sectors, after 1980.

Just as computers are increasingly affecting the conduct of professional and leisure activities, the demand for computer-based education, training, and recreation in schools, on the job, and in homes will also increase. In all years through 2000 Scenario S3 assumes far more computer-based courses per student and more teacher training than Scenario S2. It also postulates on-the-job training in more sectors and for a greater number of occupations.

The dynamic input-output model used in this study requires that projections of final deliveries other than investment--essentially the level and composition of future public and private consumption--be provided from outside the model. For present purposes the same BLS final demand projections (excluding deliveries for investment purposes) were used in Scenarios S1, S2 and S3 so that differences in scenario outcomes have to be attributed exclusively to the different technological assumptions.

We have not yet examined first-hand in detail the implications of technological and demographic change for the future input structures of households, of technological change and alternative government policy for the input structures of the various federal, state and local public administration functions, or of technological change and related shifts in international comparative advantage for the composition of U.S. exports and imports. Under these circumstances we decided that the best starting point would be the BLS final demand projections which, however, have been revised upwards with respect to the use of computers by the military and by households.

Scenario S4 is identical to S3 in all of its assumptions about the technological structure of the economy but the projections of final deliveries incorporated in it are different from those used in the third as well as the first and second Scenarios. For Scenario S4, future employment was fixed at levels corresponding to official projections of the total U.S. labor force; the results of the computation show the future rates of growth of final deliveries that could be attained within the constraints of available labor and under the technological assumptions of Scenario S3.

3. Conclusions

The results of this study show that the intensive use of automation will make it possible to achieve over the next 20 years significant economies in labor relative to the production of the same bills of goods with the mix of technologies currently in use. Over 11 million fewer workers are required in 1990, and over 20 million fewer in 2000, under Scenario S3 compared to S1: this represents a saving of 8.5% and 11.7%, respectively, of the reference scenario labor requirements (see Table 1).

The composition and level of employment in 1978 under Scenarios S1, S2, and S3 are shown in Table 1.1. BLS estimates for the same year are included for comparison. Since the BLS sectoral direct labor coefficients were used in the IEA database, it is not surprising that the two sets of estimates for the economy as a whole are within 1% of each other.

The impacts of automation are different for different types of work, and this is apparent even in terms of the 9 broad categories of labor shown in Tables 1 and 2. By 1990 there is a progressive increase in the proportion of professionals and a steep reduction in the number and proportion of clerical workers as we move from Scenario S1 through S2 to S3.

By the year 2000, professionals will account for nearly 20% of all labor requirements under Scenairo S3 compared to 15.6% in 1978, and demand for clerical workers falls to 11.5% from 17.8% in 1978. The demand for managers also slackens noticeably by 2000 under Scenario S3, and in absolute numbers

Table 1. Levels of Employment[a] under Scenarios S1, S2, and S3 in 1978, 1990 and 2000 (millions of person-years)

		Scenarios S1, S2, and S3	BLS Estimates[b]
1978	Professionals	13.9	13.3
	Managers	9.5	9.6
	Sales Workers	5.9	5.9
	Clerical Workers	15.9	15.6
	Craftsmen	11.8	12.0
	Operatives	14.0	14.3
	Service Workers	11.1	10.6
	Laborers	4.3	4.5
	Farmers	2.8	2.8
	Total	89.2	88.6

		Scenario S1	Scenario S2	Scenario S3
1990	Professionals	19.8	21.2	20.9
	Managers	14.4	14.4	12.4
	Sales Workers	9.1	8.9	8.2
	Clerical Workers	24.7	21.2	16.7
	Craftsmen	18.0	17.9	17.5
	Operatives	22.0	21.8	21.1
	Service Workers	16.7	16.8	16.8
	Laborers	6.6	6.6	6.4
	Farmers	4.2	4.2	4.2
	Total	135.5	132.9	124.1
2000	Professionals	25.6	28.4	31.1
	Managers	19.0	17.1	11.2
	Sales Workers	12.4	11.8	10.2
	Clerical Workers	32.6	25.0	17.9
	Craftsmen	23.3	22.9	23.4
	Operatives	27.6	26.1	25.8
	Service Workers	22.3	22.4	23.0
	Laborers	8.7	8.6	8.7
	Farmers	5.3	5.3	5.4
	Total	176.8	167.7	156.6

[a] Includes all private sector employment (jobs) plus employment in public education and health. Does not include public administration, armed forces, or household employees.

[b] Calculated from [U.S. Department of Labor, 1981] using the employment definitions of the IEA Model.

Table 2. Composition of Employment^{a} under Scenarios S1, S2, and S3 in 1978, 1990 and 2000 (percentages)

		Scenarios S1, S2,and S3	BLS Estimates^{b}
1978	Professionals	15.6	15.0
	Managers	9.5	10.8
	Sales Workers	6.6	6.7
	Clerical Workers	17.8	17.7
	Craftsmen	13.3	13.6
	Operatives	15.7	16.1
	Service Workers	12.4	12.0
	Laborers	4.9	5.0
	Farmers	3.2	3.2
	Total	100.0	100.0

		Scenario S1	Scenario S2	Scenario S3
1990	Professionals	14.6	16.0	16.8
	Managers	10.6	10.8	10.0
	Sales Workers	6.7	6.7	6.6
	Clerical Workers	18.2	15.9	13.5
	Craftsmen	13.3	13.5	14.1
	Operatives	16.3	16.4	17.0
	Service Workers	12.3	12.6	13.5
	Laborers	4.9	4.9	5.2
	Farmers	3.1	3.1	3.3
	Total	100.0	100.0	100.0
2000	Professionals	14.5	16.9	19.8
	Managers	10.8	10.2	7.2
	Sales Workers	7.0	7.0	6.5
	Clerical Workers	18.4	14.9	11.4
	Craftsmen	13.2	13.7	15.0
	Operatives	15.6	15.6	16.5
	Service Workers	12.6	13.4	14.7
	Laborers	4.9	5.1	5.5
	Farmers	3.0	3.2	3.4
	Total	100.0	100.0	100.0

[a,b] See Table 1.

is lower than in 1990 even though in the aggregate 32 million workers have been added to the labor force by the end of the decade according to this scenario.

Inspection of the labor requirements at the level of detail of 53 occupations shows that the increased demand for professionals is mainly for computer specialists and engineers while the demand for all categories of clerical workers is significantly lower under Scenario S3 than S1.

The projected demand for construction craftsmen has a markedly different pattern than that which has been discussed so far: it follows the cycles of the investment demand for structures, and the peaks under Scenario S3 reflect the increased demand for capital. The sharp fall in demand for skilled metalworkers reflects in part the increased use of CNC machine tools.

The impacts of robots on demand for the affected semiskilled occupations and laborers is much more modest. While the reduction in demand for these categories of workers, which is directly attributable to robots, is about 400,000 in 1990 and almost two million in 2000 under Scenario S3, the net demand is about the same as under Scenario S1, apparently due to the offsetting effects of increased production of capital goods.

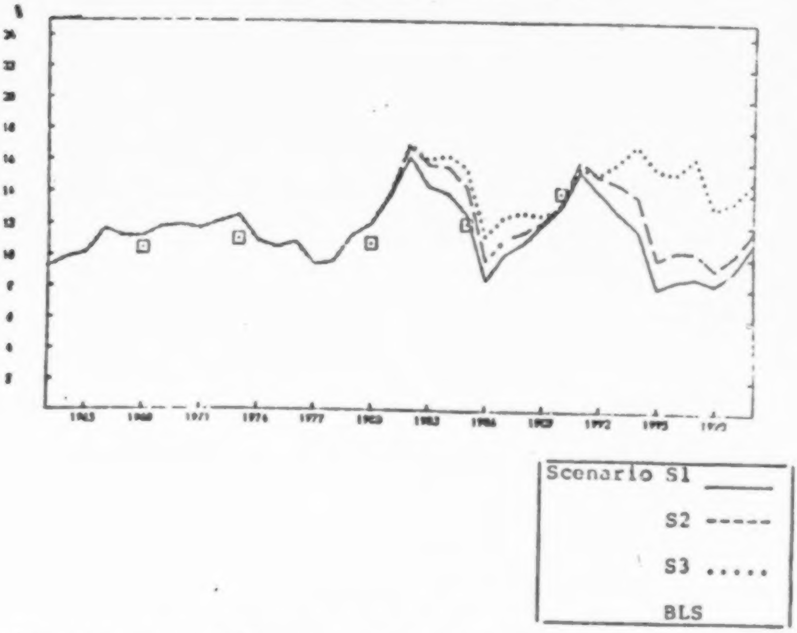
For most sectors increases in output are accompanied by reductions in employment under Scenario S3 as compared to S1, particularly for many of the metal-working sectors and semiconductors. While employment in the computer sector increases substantially, output grows at a much greater rate. Under the given assumptions--in particular, the same deliveries to final demand (except investment) for all scenarios--the demand for output of most service sectors is about the same under alternative scenarios, and the labor savings in the service sectors due to office automation are very large.

The proportion of employment absorbed in the production of capital goods varies considerably from occupation to occupation. While there are differences over time and across scenarios, it appears that 5-6% of the private economy labor force is employed directly or indirectly in the production of the private economy's capital goods. About 12-15% of craftsmen are involved in the production of capital goods, 9-11% of laborers, and a somewhat smaller percentage of operatives. As could be anticipated, practically no agricultural workers and barely 1% of service workers are involved. While under most scenarios for most years only 2-3% of professionals are so engaged, this rises to slightly more than 4% by 2000 under Scenario S3.

Annual investment as a percentage of total final deliveries is higher under Scenario S3 than Scenarios S1 and S3 since the labor savings discussed eariier are, naturally, in part made possible by the substitution of capital for labor. This is shown in Figure 1.

During both decades 1981-1990 and 1991-2000, about half the value of the additional investment under Scenario S3 as compared with S1 (or S2) is for computers. Total investment is about 1% higher under Scenario S3 than S1 in the 1990's and 59% higher in the 1990's.

Figure 1. Investment as a Percentage of Total Final Deliveries,[a] 1963-2000

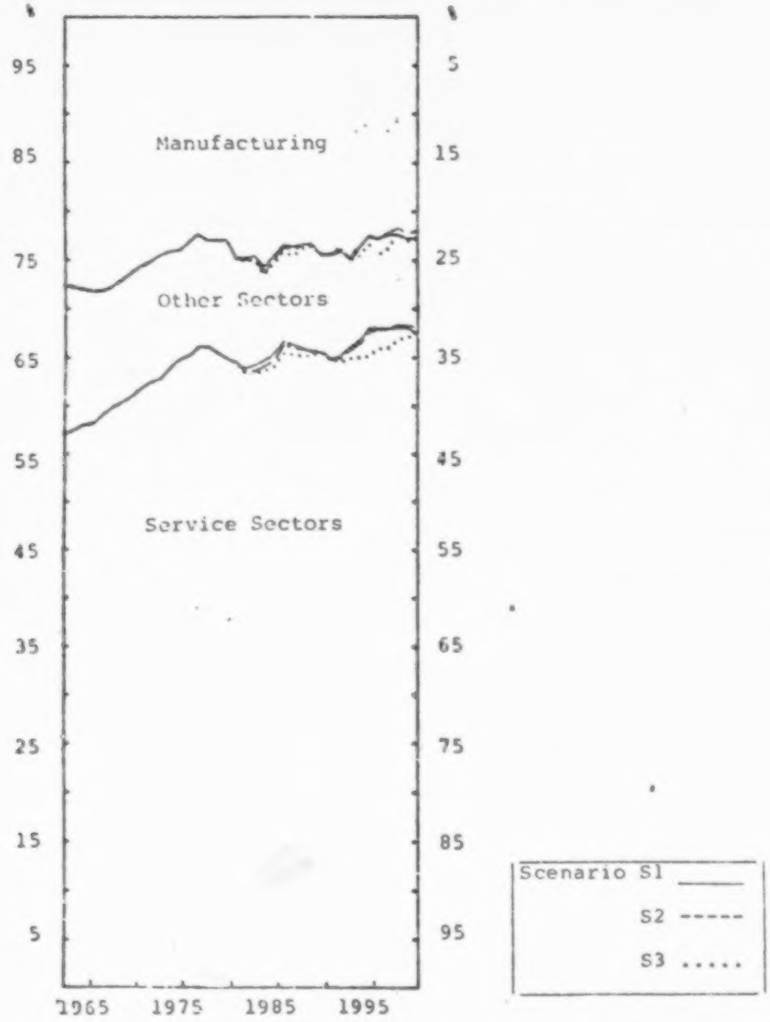


[a] Investment is defined as gross private fixed capital formation, including investment for public education and health care. Total final deliveries inlcude investment.

Source of BLS figures: [U.S. Department of Labor, 1982, p. 14].

The increasing use of automatic equipment involves shifts not only in the occupational but also in the sectoral distribution of the work force, with the increased production of capital goods slowing the transfer from manufacturing to service sector employment over the next twenty years. This is seen in Figure 2, which is a graphic presentation of the percentage of employment in manufacturing, service, and other sectors between 1963 and 2000.

Figure 2. Percentage Distribution of Employment among Service, Manufacturing, and Other Sectors, 1963-2000



Note: Manufacturing is defined to include IEA #12-66 and 86. The residual category, Other Sectors, includes Agriculture (IEA #1-4), Mining (IEA #5-10), and Construction (IEA #11). All remaining sectors are included as Services.

Scenario S3 assumes the accelerated adoption through the year 2000 of computer-based automation into all sectors of the economy, accompanied by a continual increase in the material standard of living. While investment is computed within the IEA model, the other components of final deliveries (personal consumption, government purchases, and net exports) are prescribed, based on BLS projections, to grow over the next twenty years at about 2% a year under the high population projections.

The first row of Table 3 shows the levels of employment which according to the IEA model would be required in order to satisfy this growth in total final deliveries under the technological assumptions of Scenario S3. The first four entries of the third row show data for the same employment concept prepared from government sources for benchmark years between 1963 and 1977, and the match with the IEA results is excellent. For 1990, the projection based on BLS assumptions (which are described in the notes to the table) is presented as a range of low to high. Since no comparable figures have been projected for 2000, we include in the last row of the row of the table civilian labor force projections for the purpose of comparison with the IEA employment projections. The difference between the employment concept of the first three rows and the civilian labor force is that the latter measures persons rather than jobs and includes both the unemployed and those employed in households and public administration. For the years shown between 1963 and 1977, this difference amounts to between 6 1/2 and 10 million.

Table 3. U.S. Employment Under Scenarios S3 and S4[a] and Other Sources, 1963-2000

	1963	1967	1972	1977	1990	2000
IEA Employment[b] Estimates and Projections						
Scenario S3	62.8	69.6	78.2	86.2	124.1	156.6
Scenario S4	62.8	69.6	78.2	86.2	115.3	128.2
Actual and Projected Employment from Other sources[b,c]	62.8	70.9	78.1	87.4	111.0- 123.9	not available
Actual and Projected Civilian Labor Force[d]	71.8	77.3	86.5	97.4	123.9- 138.3	132.8- 157.4

[a] See text for description of Scenario S4.

[b] Includes private sector employment (jobs) plus employment in public education and health. Excludes public administration, armed forces, and household workers.

[c] Entries for 1963-1977 are from [U.S. Department of Commerce, 1981, 1982a]. The ratio of "business" employment (as defined in note 'a') to civilian labor force projected by the BLS for 1990 [U.S. Department of Labor, 1981] was applied to the civilian labor force projections for 1990 which are given in this table. The BLS has not projected figures for 2000. Figures for 1990 and 2000 are reported as a range from low to high.

[d] Entries for 1963-1977 are from [U.S. Department of Labor, 1980]. The range of projections for 1990 and 2000 are based on the most recent population estimates summarized in [U.S. Department of Commerce, 1982b] and rates of participation in the labor force of the portion of the population over age 16 [U.S. Department of Labor, 1982a, Appendix C]. The lowest projection, for example, is calculated from the lowest participation rate and the over-16 portion of the lowest population projection.

Projected labor requirements under Scenario S3 for 1990 fall at the upper limit of the BLS-based projection of 124 million (and the latter assumes an exogenous unemployment rate of about 4%).

Looking further into the future, if the civilian labor force projections reported in the table are accepted, the projected labor requirements of 156.6 million under Scenario S3 for the year 2000 exceed the available labor force (because even a maximum civilian labor force of 157.4 million must allow for public administration, household workers, and some multiple job-holders). Thus the rate of growth in final deliveries that has been assumed under Scenario S3, based on BLS projections, could not be achieved through only those aspects of technological change that have been represented in this scenario.

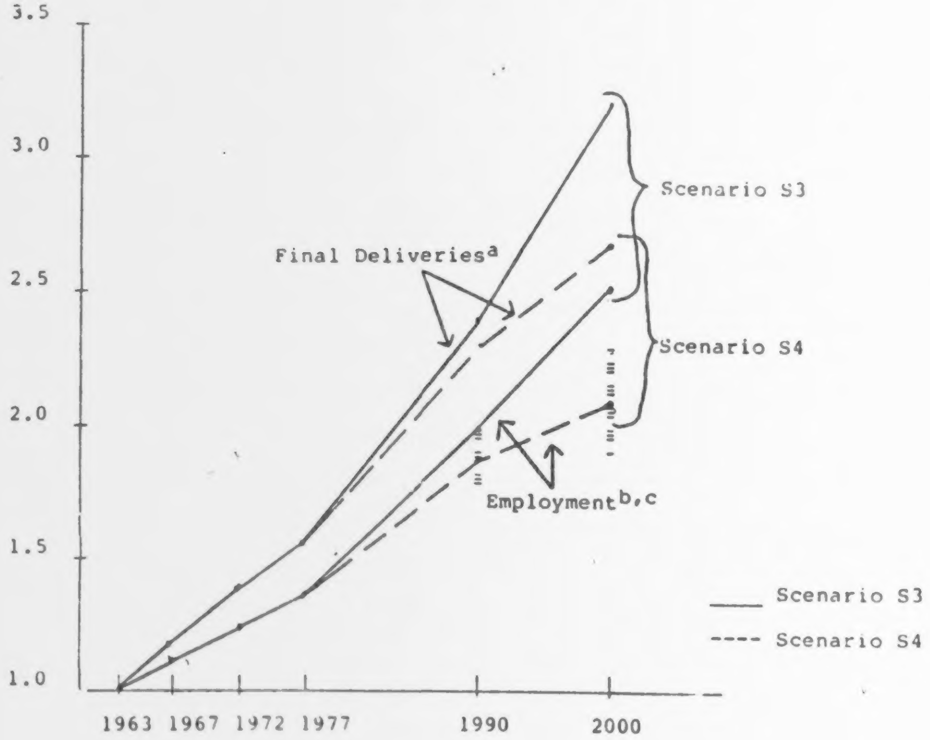
The fourth scenario, S4, was formulated to assess what future rates of growth of final deliveries could actually be attained within the constraints of available labor, according to current labor force projections, and under the technological assumptions of Scenario S3. For Scenario S4 we progressively reduced the level, while maintaining the compositon, of final deliveries prescribed by Scenario S3 for 1990 and 2000 (and accordingly also for years between 1980 and 1990 and between 1990 and 2000). For each sequence of final deliveries up to the year 2000, the corresponding labor requirements were computed. The procedure was repeated until the computed labor required for 1990 and for 2000 fell within the range of labor force projections reported in Table 3.

When the value (in 1979 prices) of final deliveries excluding investment under Scenario S3 (based on BLS projections) is reduced by 4.4% in 1990 and 16.8% in 2000 the aggregate employment requirements under Scenario S4 fall within the range of the projected labor force (Table 3). Because overall economic activity is lower under Scenario S4 than S3, there will be less investment. For this reason the percentage reduction in the demand for labor as compared to that of Scenario S3 is even greater than that of final deliveries. For any given year, the occupational composition of employment turns out to be virtually identical under Scenarios S3 and S4, with a lower representation under S4 of those engaged particularly in the production of capital goods; for example, craftsmen represent 14.7% of the employed in 2000 compared to 15.0% under Scenario S3.

Under Scenario S4, per capita final deliveries grow at about 2% a year through the 1980's and about 1.0-0.5%, corresponding respectively to low and high population projections, through the 1990's. This is an estimate of the extent to which real per capita consumption will be able to increase over the next two decades if the entire projected labor force is employed using the progressively phased-in computer based technologies. Figure 3 summarizes the differences in postulated aggregate final deliveries and resulting levels of employment between Scenarios S3 and S4.

Figure 3. Growth in Final Deliveries[a] and Employment[b] under Scenarios S3 and S4, 1963-2000

(1963 = 1.0)



[a] Final deliveries include goods and services for public and personal consumption and net exports. Gross private fixed non-residential investment is excluded.

[b] See note b, Table 3.

[c] Hashed lines (≡) show range of employment projections based on official sources. The range for 2000 assumes the same employment to civilian labor force ratios as given in Table 3 for 1990.

Based on the computations presented in this report, it is not yet possible to pass a final verdict on the question of technological unemployment by the year 2000. Technological change taken into account in the scenarios described in this report has been limited to certain aspects of computer-based automation. It will be necessary to ascertain by equally detailed factual inquiry and to incorporate into the technical matrices used in these projections other types of change that are bound to take place, for example in agriculture and in the substitution of materials--like plastics for metals on the one hand and for paper on the other. Moreover, we have explicitly excluded from our scenarios any major breakthroughs in computer technology that might affect significant numbers of workers before the year 2000. While it is likely to be at least twenty years before products embodying future breakthroughs in areas such as automatic programming, speech recognition, or robot vision are actually adopted on a large scale, some surprises are certainly possible.

The great industrial revolution inaugurated by the introduction of mechanical power continued to transform western economy and society over a period of some two hundred years. The electronic revolution became visible only a few years ago, and by the year 2000 it will be not more advanced than the mechanization of the European economies had advanced, say, by the year 1820.

A major consideration in realizing the transition from the old to new technologies will be the availability of workers with the training and skills that match the work that needs to be done. According to Scenario S3, labor requirements to satisfy a continually but moderately increasing standard of living will number 124 million jobs in 1990 with the required occupational composition, reflecting the technologies that will be in place (given in Table 2). Let us suppose that there is an adequate total number of individuals to fill these jobs, but that because of very slow change in the orientation of education, training, guidance, and so on, these individuals' skills and occupational expectations will reflect the mix of jobs that corresponded to the technologies that were in place in 1978. Under these assumptions, 744,0000 managers (0.6% of 124 million), and over five million clerical workers would be potentially unemployed in 1990 while there would be unfilled positions (in the same total amount under the present simple assumptions) in the other aggregate occupational categories. Of course some of those seeking managerial and clerical employment would be able to find jobs of other kinds but with obvious limitations on the degree of job mobility.

The same considerations apply within each broad occupational category. Among professionals, for example, the IEA employment projections for 1990 show a greater proportion of engineers and especially of computer specialists than in 1978. Among skilled workers, the projections include a higher proportion of foremen and production mechanics and a lower proportion of construction and metal-working craftsmen than in 1978.

The crude experiment described above provides of course only a very rough approximation of the ability of the future labor force to fulfill specific job requirements. An adequate evaluation will require comparably detailed analysis of the future structure of households and the job-related attributes of their members. This has not yet been carried out.

Concerted efforts in education and training can facilitate shifting the occupational composition of the labor force. Scenario S3 requires that the production of electronic educational courseware grow in real terms at over 35% a year in the 1980's and over 10% in the 1990's. In the past, higher levels of "conventional" education in the U.S. relative to other countries also played a key role in the successful transformation of our labor force from mainly agricultural workers into a wide range of other occupations. As was the case in the past for conventional education, the growth and quality of computer-based education and its delivery will no doubt become an item of government policy and corporate and trade union strategies.

This study has taken a first systematic albeit partial glance at prospects for employment for almost twenty years into the future, a significant lengthening of the usual time horizon for economic inquiry. With the feasibility and fruitfulness the approach taken in this study now hopefully demonstrated, we need to extend and improve the sector studies on which the scenarios are based and investigate the impacts on the distribution of income implied by the technological assumptions. It will also be necessary, instead of taking final deliveries as given, to formulate and implement a completely closed dynamic input-output model in which consumption and employment are determined simultaneously. These are some of the next steps in our agenda.

In the meantime, the framework developed for this study can profitably be used to investigate numerous critical economic issues which have until now not been subject to systematic inquiry.

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